VOL. XLVI, NUMBER 1 WHOLE NUMBER 394

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR, C. A. CHANT ASSISTANT EDITOR, RUTH J. NORTHCOTT

David Dunlap Observatory
Richmond Hill P.O., Ont.

ASSOCIATE EDITORS:

C. S. BEALS
Dominion Astronomer
Ottawa

R. M. PETRIE
Dominion Astrophysicist
Victoria, B.C.

A. THOMSON
Controller of the Meteorological Service of Canada, Toronto

PUBLISHED BI-MONTHLY
(Six numbers per year)

January-February, 1952

PRINTED FOR THE SOCIETY
TORONTO: 3 WILLCOCKS ST.

The Royal Astronomical Society of Canada

OFFICERS FOR 1951

NATIONAL OFFICERS AND COUNCIL

Honorary President—The Honourable DANA A. PORTER, Minister of Education for the Province of Ontario.
President—C. S. BEALS, Ph.D., Ottawa.
First Vice-President—J. F. HEARD, Ph.D., Toronto.
Second Vice-President—DELISLE GARNEAU, Montreal.
National Secretary—E. J. A. KENNEDY, 3 Willcocks St., Toronto.
National Treasurer—J. H. HORNING, M.A., 3 Willcocks St., Toronto.
Recorder—H. W. BARKER,* Toronto. *Librarian*—D. W. BEST, D.D., Toronto.
Council—CHARLES A. BELL, B.A., Windsor; BALFOUR W. CURRIE, Saskatoon; F. DEKINDER, Montreal; DELISLE GARNEAU, Montreal; CHARLES A. GIROUX, Quebec; E. S. KEEPING, M.A., Edmonton; D. A. MACLULICH, Ph.D., Ottawa; GORDON R. MAGEE, Ph.D., London; Rev. E. F. MAUNSELL, M.A., Hamilton; R. C. MOFFATT, Guelph; RAYMOND PEARCE, Toronto; GORDON SHAW, Victoria; G. M. SHRUM, Ph.D., Vancouver; J. A. WHITE, Winnipeg.

*Deceased.

TORONTO CENTRE

Honorary President—C. A. CHANT, Ph.D. *President*—F. L. TROYER.
First Vice-President—R. E. WILLIAMSON, Ph.D.
Second Vice-President—RAYMOND PEARCE.
Secretary—JOHN GALT, 43 Adelaide St. E., Toronto.
Treasurer—T. H. MASON. *Recorder*—W. R. HOSSACK.
Council—Miss BARBARA CREEPER; C. A. CROOK; GEORGE T. DALE; DAVID GERRIE; Mrs. K. M. HEATON; GORDON HEPBURN, B.A.Sc.; A. MILNE; W. R. SHERRICK; NORMAN N. WRONG, M.D.; and *Past Presidents*—E. J. A. KENNEDY; J. R. COLLINS; S. C. BROWN; D. W. BEST, D.D.; Miss RUTH J. NORTHCOTT, M.A.; J. F. HEARD, Ph.D.; A. R. CLUTE, K.C.

OTTAWA CENTRE

Honorary President—R. MELDRUM STEWART. *President*—JAMES HARGREAVES.
First Vice-President—M. J. S. INNES. *Second Vice-President*—D. A. MACLULICH.
Secretary—R. W. TANNER, Dominion Observatory, Ottawa. *Treasurer*—S. A. MOTT.
Council—A. E. COVINGTON; C. M. CROSS; J. L. LOCKE; F. W. MAILEY; ETHEL STEACY.

HAMILTON CENTRE

Honorary President—W. T. GODDARD. *President*—W. J. MCCALLION, M.A.
Vice-President—O. J. PATON.
Secretary-Treasurer—GEORGE MURCHIE, 77 Fennel Avenue, W., Hamilton.
Curator—G. E. CAMPBELL, M.A.
Council—F. SCHNEIDER; F. SISMAN; L. O. JONES; B. WISHART; DR. MARTIN JOHNS; L. W. WELBOURN; and *Past Presidents*—REV. E. F. MAUNSELL; T. M. NORTON; W. S. MALLORY; DR. A. E. JOHNS; W. D. STEWART; H. B. FOX.

WINNIPEG CENTRE

Honorary President—L. T. S. NORRIS-ELYE. *President*—E. R. GARDNER.
Vice-President—H. E. RASMUSSEN. *Treasurer*—Miss M. E. WATIERSON.
Secretary—A. J. VINCENT, 919 Grain Exchange, Winnipeg.
Council—Miss O. A. ARMSTRONG; C. CARD; D. R. P. COATS; V. JONES; F. SHANKS.

VICTORIA CENTRE

Honorary President—A. MCKELLAR, Ph.D. *President*—Mrs. J. R. NOBLE.
First Vice-President—R. S. EVANS. *Second Vice-President*—E. H. POPE.
Secretary-Treasurer—JOHN JERVIS, 1870 Cedar Hill Crossroad, Victoria.
Recorder—MAJOR E. R. GIBSON. *Librarian*—JOHN CLIMENHAGA.
Director of Telescopes—R. PETERS.
Council—S. H. DRAPER; D. P. MCALPINE; F. T. NAISH; N. G. ROGERS; A. STOCKS; ANNE B. UNDERHILL, Ph.D.; F. R. WILLIAMS.

MONTREAL CENTRE

Honorary President—G. HARPER HALL.
Honorary Vice-President—A. NORMAN SHAW, Ph.D.
President—Miss I. K. WILLIAMSON. *Vice-President*—D. E. DOUGLAS, Ph.D.
Secretary—HENRY F. HALL, 1441 Drummond Street, Montreal. *Treasurer*—C. N. S. YARNELL.
Recorder—E. E. BRIGDEN. *Director of Observations*—F. DEKINDER.
Librarian—C. M. GOOD.
Council—T. D. ARCHIBALD; W. H. BIRTLES; A. M. DONNELLY; DELISLE GARNEAU; ANNA I. MCPHERSON, Ph.D.; A. R. MACLENNAN; T. O. PLANT; PAUL SCOTT; R. O. STEVENSON; R. VENOR; and *Past President*—J. W. DUFFIE.

PRINTED IN CANADA

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY
OF CANADA

VOL. XLVI, NO. 1 JANUARY-FEBRUARY, 1952 WHOLE NO. 394

THE STORY OF PLUTO*

BY DINSMORE ALTER

THE story of the planet Pluto begins on the 13th of March 1781. It is a story which ties itself very closely to three amateur astronomers who, because of their successful work, became well-known professionals. From that night in 1781 when William Herschel discovered the first planet that had not been known from prehistoric times, the sequence of events has been almost inexorable.

The story of Herschel was told by Dr. Cleminshaw in the July 1940 issue of the *Griffith Observer*. Herschel at the time was examining some fields of faint stars in the constellation of Gemini. His purpose was an attempt to determine the parallax of the stars, a matter in which he had great hope of success, although eventually he failed. One star lacked the sparkle of the others and in addition appeared to be a little larger. This difference caused him to suspect that the star was a comet. He used various eyepieces in examining it, all the way from 227 to 932 diameters. Since stars do not have real disks of large enough angular diameter for direct observation, increase in the magnifying power does not increase the size of the apparent disk proportionately.

He wrote, "The comet being magnified much beyond what its light would admit of, appeared hazy and ill-defined with these great powers, while the stars preserved that lustre and distinctness which from many thousand observations I knew they would retain." He observed it several times and wrote on the 6th of April, "With a magnifying power of 278 times the Comet appeared perfectly sharp upon the edges, and extremely well defined, without the least appearance of any beard or tail."

It was difficult with the method then available to compute the orbit of a comet but eventually the calculations showed that Herschel's new

*A paper prepared for publication in the *Griffith Observer*. Dr. Alter supplied a duplicate copy of the manuscript for publication in this JOURNAL.

object was not a comet but actually was a planet. King George III had been his patron in his profession of music, and Herschel proposed that the planet be named after him. Some desired to name it after Herschel himself, but eventually the old scheme of planet naming was adopted, and Uranus was chosen as the name.

The discovery reversed Herschel's profession and avocation. Friends of Herschel's, especially Sir Joseph Banks and Dr. W. Watson, made representations to the King concerning him and his work and urged that Herschel be made independent of the practice of music. On July 14th Dr. Watson wrote the following letter to him:[1]

My dear Friend,

I need not tell you with what satisfaction I received the account of the King's offer to make you independent of music, and was in hopes before now of hearing further the mode in which it is to be put in execution. You are now upon the eve of entering into a new course of life, to take upon you a new character, and to be in a situation which will at the same time command respect and what is still more desirable, enable you wholly to give up yourself to an employment which is attended with the highest gratification.

I presume General Freitag is a German, you would do well to cultivate his acquaintance, for as the King thought proper to make him the messenger of his offer, he will be the most proper person thro' whom you may communicate to the King anything you may wish to have him informed of relative to this business. . . .

Sir Joseph Banks sent me an answer to mine in which he mentions the anxious wishes he had of serving you and how often he had weighed in his mind how it was to be effected and how much he was perplexed with a thousand delicacies, and that he had actually come to Town on Thursday morning in order to inquire after you and to consult with you what was to be done, being by no means satisfied with himself. He then heard of the offer the King made and expresses the pleasure he received at the news in the warmest manner. I thought it proper to tell you this, that you might see that tho' it was not in his power to speak to the King of late, he nevertheless felt great zeal for your service, and has a very great regard for you.

Permit me, my dear Friend, once more to congratulate you on this great event of your life, and to assure you that my satisfaction on this occasion can fall very little short of what you yourself must feel.

I am, Dear Sir,

Your most sincere friend,

W. Watson.

The income granted by the King was supplemented by construction of telescopes for sale. From these Herschel derived a considerable income.

Uranus had been observed nineteen times by other astronomers before it was viewed by Herschel, but each observer had supposed it

[1]Copied from C. A. Lubbock's book, *The Herschel Chronicle*, Cambridge University Press, 1933.

to be a star and had recorded it as such. The first such observation was by Flamsteed in 1690. These observations aided very much in an early determination of a rather accurate orbit. By 1790 the Academy of Sciences of Paris offered a prize for the best solution of the problem of its orbit. This solution was to take into account not only the attraction of the sun, but also the *perturbations* produced by Jupiter and Saturn. The famous French mathematical astronomer, Delandres, won the prize. He was able to represent the ancient observations as well as the recent ones within the limit of accuracy expected of them and published an ephemeris for future positions.

As years went by an increasing discrepancy was observed between prediction and observation. Bouvard by 1821 found that although he could use one elliptical orbit to account for the older observations and another for the newer ones, it was impossible to find one which would combine all of them. He decided that the inherent inaccuracy of the old observations was sufficient that the difficulty should be resolved by discarding them, rather than by assuming the impossibility of one mean ellipse corrected for perturbations by Jupiter and Saturn to be used for all. Nevertheless, he stated that the future might show the discarded hypothesis to be the correct one. He never abandoned the possibility of an unknown planet causing the trouble.

After only a few years, discrepancies began to appear and these continually increased. Two other hypotheses were considered tentatively, one that the law of gravitation was not exactly accurate and that at the great distance of Uranus from the sun the deviations began to appear. The other was that collision with some body, perhaps a comet, had produced an actual discontinuity. Neither of these was seriously entertained by astronomers. The discussion was general and searches were proposed. By 1841 the residuals had grown to 71 seconds of arc, many times any possible error.

Perhaps Bessel was the first to suggest that the very tedious and difficult perturbation problem be worked *backwards* and that the residuals left after the effects of Jupiter and Saturn had been eliminated should be used to locate an unknown planet which had produced them. The direct problem of perturbations uses the mass and orbit of a planet as known and computes the effects on the second planet. These, as had been done for Jupiter and Saturn in the Uranus problem, are used for prediction purposes. The reverse problem interchanges the known and the unknown quantities and solves for the mass and orbit of an unknown planet.

There appeared to be one simplification which could aid the

computer. Bode's law predicted the distance of the next planet out from the sun as 38.8 times that of the earth. The discoveries of Uranus and the asteroids after its formulation had confirmed the law. The reasonable approach, under the conditions then known, was to assume that the unknown planet was at this known distance from the sun. If the assumption were seriously in error it would result in prediction of a planet with a different orbit and an incorrect mass. If, during the interval considered, the unknown planet had actually moved too far in its orbit, no solution could be found. If, on the other hand, the time interval was not too long, the solution, although giving a fictitious orbit, would nevertheless give roughly the true direction of the known planet at the time of the calculation. Astronomers knew that a planet at the assumed distance would require about 250 years to complete one revolution. An error in the asumed distance would not, therefore, be too serious in searching for the new body.

Two astronomers, young John Couch Adams at Cambridge and the French astronomer Leverrier, attacked the problem independently and each without knowledge of the other's work. If this were primarily the story of the discovery of Neptune we should go into detail concerning Adams's earlier completion of his work, his submission of it to the Astronomer Royal, the latter's dalliance in making a search, the completion of the problem by Leverrier, his submission to the German astronomer Galle, Galle's remembrance of Herschel's discovery of Uranus from the dull appearance of the object, his prompt search and immediate visual discovery.

Leverrier, during his research, partly abandoned the Bode distance and came to a final value about two astronomical units closer. The predicted places by the two investigators, whose methods differed somewhat, were surprisingly close. They differed by only one degree, and Galle found the planet within a degree of the point predicted by Leverrier. The psychologist and the student of social sciences may study the great international controversy which was launched by newspaper editors and other persons concerning credit.

As soon as the orbit of Neptune was determined accurately, Uranus appeared to fall into place with his brothers of the solar family. Whereas residuals as large at 133″ had been observed in the position of Uranus, the maximum now observable was at most about 4″. Until the orbit of Neptune had been determined with great accuracy, such differences were tolerable, for no one could be certain exactly how much Neptune was disturbing Uranus.

Gradually as the orbits became better known, it appeared that the

residuals of Uranus were considerably larger than could be expected through error of observation and orbital uncertainties. They were not, however, large enough to demonstrate without laborious calculation that they were caused by one or more planets beyond Neptune. The problem of locating any such planet was, on account of their small size, far more difficult than in the previous case.

Early in this century two astronomers, Professor W. H. Pickering of Harvard and Dr. Percival Lowell, made independent calculations.[2] Pickering, from a different cause suffered the same bad luck as had Adams nearly a century earlier. By 1919 he had calculated a rough position for the unknown planet. This position was made the basis of a search at Mount Wilson. Unfortunately the planet was in an area of the sky where there were many faint stars and also it was far fainter than had been expected. As a result, it was not recognized, although its image was found later on four of the plates taken in 1919!

Perhaps Pickering himself was convinced by the search that no such one planet existed, for later he published work based on a plurality of unknown planets. Certainly in 1930 he did not believe at first that the object found could be a planet.

Lowell's calculations were similar to those made by Leverrier. They were carried out carefully and followed, from a mathematical point of view, a more elegant method than that used by Pickering. However, they gave two opposite areas in the sky in either of which the planet might exist. The problem of perturbations is very similar to the "ideal" problem of tides. As everyone knows, the moon produces almost identical high tidal forces when it is high overhead and when it is farthest below the horizon. If we had to infer the existence of the moon from such data, we would be uncertain in which half of the sky to search. Pickering's different method, although less accurate, did discriminate between these positions.

Percival Lowell was an extremely interesting man, actually an amateur but one who built an observatory to rank very high among the observatories of the world and who not only devoted all of his own time to astronomy but engaged a staff of professional astronomers to assist him. He is best known to the public for his studies of the planet Mars, for it was that planet which turned him toward the science.

Lowell began his studies of the Uranian discrepancies about 1905.

[2]An unusually good summary of the work of these two men appears as part of a paper by Dr. V. Kourganoff. "La part de la Mécanique Céleste dans la découverte de Pluton," *B.A.*, t XII, Fasc. IV, p. 147; Fasc. V, p. 271; Fasc. VI, p. 303, 1940; *Ciel et Terre*, vol. 60, p. 180, 1944. See also "Kourganoff's Contributions to the History of the Discovery of Pluto," by Gibson Reaves, *Pub. A.S.P.*, vol. 63, p. 49, 1951.

From then on for a quarter of a century (with a few interruptions) his staff continued a photographic search for the unknown distant planet. In 1914 he published in detail the results of his calculations and during the two remaining years of his life watched the observations impatiently.

Thirteen years after his death a special telescope (or camera) was installed to push the search more determinedly. This was a 13-inch astrographic camera. Such a camera makes photographs of the sky on large plates, each of which covers a much larger area of the sky than is done by ordinary telescopes. The one installed at Lowell Observatory uses plates 14×17 inches. This instrument was named in honour of the founder's brother, Lawrence Lowell, former president of Harvard. A young man, Clyde Tombaugh, was assigned to carry out the search with this new telescope.

I knew Clyde Tombaugh very well, for after the discovery of Pluto he entered the University of Kansas and was my student for three years. I know of no more careful nor skilful observer among to-day's astronomers. He was 24 when the discovery was made.

Tombaugh was raised in Illinois and Kansas and had graduated from high school in 1925. With his father he was a wheat farmer but an enthusiastic amateur astronomer, who devoted his winters to building telescopes and reading astronomical books. In 1928 he offered to go to Lowell Observatory to do any sort of work to which he was assigned. Fortunately Slipher and Lampland recognized his abilities and assigned him to an intense search with the new telescope just one year before the discovery.

Each plate was covered with images of thousands of stars. The method was to compare two plates of each area in order to find some image which showed a shift of position between exposures. Such comparison would require months of work for each pair of plates if astronomers had not invented a special blink comparator. Two of the plates taken, say, two days apart, are placed in it side by side with each illuminated by light coming through it. An eyepiece is used with prisms so placed that the same area can be seen simultaneously in both plates. An arrangement rapidly alternates the view of the plates. All objects which have not changed either position or brightness between the exposures look exactly the same from both plates. However, any object which has moved appears to jump backward and forward rapidly and thus quickly attracts the attention of the observer. Often such shifts were found but the objects proved to be asteroids. At other times changes were observed but were due to variability of light from a star.

When the area within which the object was expected had been half examined, Tombaugh at last found the expected shift in position between

a point on two plates, although the object was fainter than expected. This was on the 24th of January 1930. The plates had been exposed on January 21 and 23. His year of hard work was rewarded. He took his result to the Director, Dr. V. M. Slipher, for confirmation. During the next month and a half, Dr. Lampland secured the most accurate possible observations of its position with the 42-inch reflector. Dr. Slipher chose March 13 to make the announcement, the 75th anniversary of Lowell's birth.

It was some time before a good enough orbit was secured to satisfy everyone that the object actually was a planet more distant than Neptune. Its period and the shape of its orbit were so uncertain that one astronomer referred to it in public lectures as the "Trans-Neptunian Comet"! I was in England at the time and had a lot of fun at some very informal dinner meetings of amateur and professional astronomers in "going out on a limb" and insisting that its period had to be either close to 250 years or double that interval. A slightly improved orbit over the first one gave a little more than 300 years as the period and, so far as I was concerned, settled the matter that eventually it would be reduced to 250 years. The true value is 248.43 years. Its mean distance from the sun is 39.5 A.U., very close to the distance for which Bode's law appeared to predict Neptune.

The orbit is more eccentric even than that of Mercury. As a result, Pluto, when closest to the sun, is nearer than Neptune. However, the plane of its orbit is such with respect to that of Neptune that no collision is possible. This is the only case of overlapping orbits of major planets although it happens very frequently in the case of asteroids.

When Neptune was discovered it was found to be closer to the sun by far than had been predicted. As a result there were those at first who believed its discovery to be merely one of the most peculiar of coincidences. This was unjustified. Although Adams and Leverrier did not have enough data to determine an accurate orbit and were misled by Bode's Law, they, nevertheless, did have sufficient facts to determine its position in the sky at that epoch.

In the case of Pluto there were also those who believed the discovery to be due merely to lucky chance. Pluto is much fainter than was expected. If it reflects light similarly to other planets it must be very small, much smaller than the earth. If of small diameter, its mass must be too small for it to disturb Uranus by a measurable amount unless it should have an unbelievably great density. Astronomers were much worried but in general felt that there must be some reconciliation, because the agreements between predicted and actual elements of its orbit scarcely could be accidental.

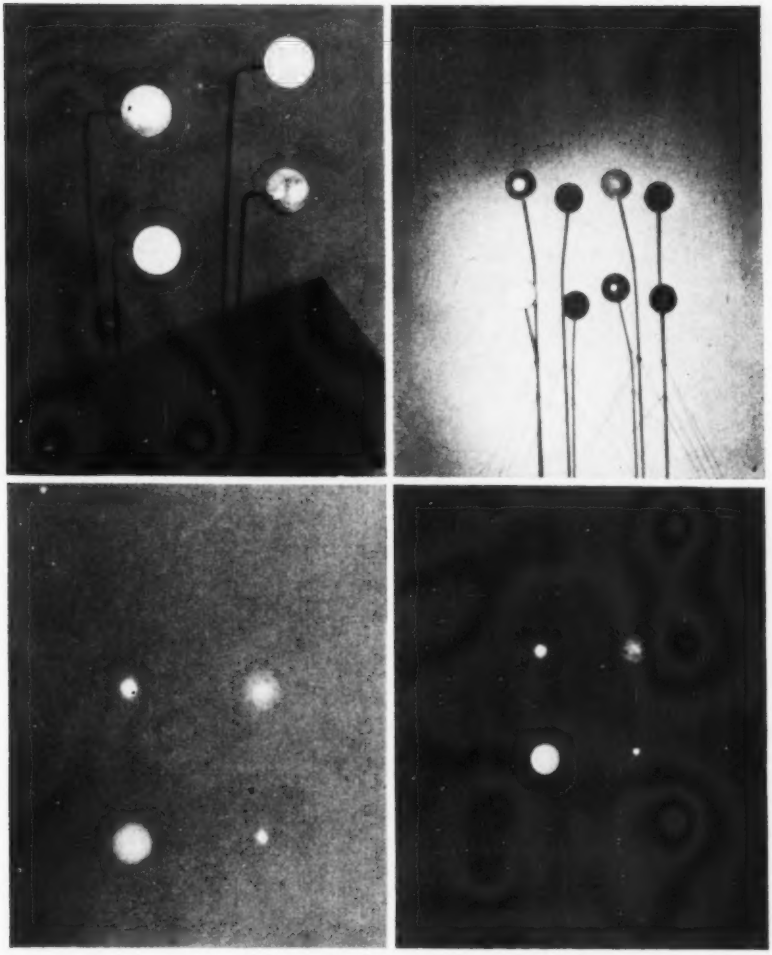
Dr. E. W. Brown of Yale, one of the most famous of the astronomers who specialized in the orbits of planets and satellites, made some calculations which he felt proved the case for coincidence. He examined the fluctuations of the residuals of Uranus itself and believed that they were such that, regardless of mass, Pluto could not have produced them. Some very able astronomers accepted his conclusions. On the other hand, there were many of us who believed that the statistical case was far too strong for any real possibility of mere coincidence to exist. The uncertainty has lasted almost to the present.

By far the most careful measurement of the diameter of Pluto was made in 1950 by Dr. Gerard P. Kuiper of the Yerkes and McDonald Observatories, using the 200-inch Hale telescope at Palomar. He employed a very ingenious illuminated disk meter device which was placed at the prime focus. Several disks of various sizes were used. Their calibration for size was made by the geometry of the disk meter and the focal length of the telescope. Dr. Kuiper estimated the uncertainty to be about 5 per cent. of the measured value. He obtained a value of 0″.23 for Pluto's diameter, giving a linear diameter of about 3,600 miles. From this measurement the reflectivity of the planet could be determined and was found to have the very reasonable value of one-sixth. We may assume that this value is the correct one for the apparent diameter of Pluto.

If the apparent value be the actual one, an impossibly high density would be required to give Pluto a mass comparable to that of the earth. Without such a mass Pluto can not possibly have produced the residual observed in the position of Uranus and Neptune. If Kuiper's value of the diameter be the true one, we certainly have experienced the most curious set of coincidences in the history of science.

There is, however, another explanation. It started as a suggestion by Sir James Jeans, quoted by Crommelin, in 1934, that perhaps the surface of Pluto reflects light more or less as does a mirror. Suppose that we could place a big polished ball, perhaps far larger than our own earth, out at the distance of Pluto. We would, from the earth, observe the sunlight which was reflected by the ball as coming only from a small area near the centre of its surface. No matter how carefully we might measure the diameter it would be far less than the diameter of the ball, since we would receive no light at all from the edge of the ball.

Let us now suppose that we had a similar ball out there, except that it was covered with patches, both of polished and of rough surface. From polished parts we could receive light only from patches close to



the centre of the surface, but the rough patches would reflect some light even from the edge. If the rough patches were big enough, we would measure the true diameter of the ball from the earth. If too small, we would not obtain enough light from the edge to observe it and would measure the ball as being smaller than it actually was.

A similar experiment on a small scale was performed this year, using four balls of equal size but with different kinds of surfaces. The upper left photograph shows the balls lighted by general illumination to reveal

the true nature of each. The lower right hand ball in this picture had a polished steel surface. Two spots of light show on it because more than one source of light was used. The lower left ball had a mat, white surface and, therefore, reflected light to the camera from all parts. The upper left ball was covered by aluminum paint which gave a sort of cross between a polished and a rough surface. The upper right ball had patches both of aluminum paint and of dark rough areas.

In the upper right and lower right photographs the balls were illuminated by a single small source to imitate the way the sun illuminates Pluto. These two pictures are identical except that in the upper picture a bright background was provided to make visible the silhouette of the actual balls. In the lower picture a dark background imitated the dark sky. The balls appear to be of entirely different sizes in this third picture.

In the lower left case, the balls were photographed at night by a 12-inch refracting telescope several hundred yards away and were illuminated by almost a point source. The same story is told as by the lower right photograph which was made with a hand camera.

From this experiment it follows that in the case of a planet whose surface characteristics are unknown, no matter how carefully the diameter may be measured, we merely obtain a minimum value. The planet may be as small as the measurement but, on the other hand, it may be far larger.

Since the perturbations of Uranus and Neptune seem definitely to give a value of its mass, which is perhaps a trifle larger than that of the earth, and since the earth is the densest of the other planets, it appears safe to estimate that the diameter of Pluto is at least as great as that of the earth.

The only apparent hope of making a true measurement is by the extremely tedious method of watching for it to occult stars. Even then quite a number of occultations would be necessary.

Much still remains to learn about Pluto. Even that frozen world appears unlikely to be the outermost member of the sun's family, but that is an entirely different story.

A SPECTROGRAPHIC STUDY OF THE DOUBLE-LINED BINARY SYSTEM H.D. 27483*

BY RUTH J. NORTHCOTT AND K. O. WRIGHT

ABSTRACT

Radial-velocity observations of the double-lined binary system H.D. 27483, made at the David Dunlap, Mount Wilson, and Dominion Astrophysical Observatories, have been combined to determine a period of 3.05911 days. The orbital elements, determined from a least-squares solution, are listed in Table I. A spectrophotometric study of spectra obtained at single- and double-lined phases has been made to determine the relative luminosity of the two components; the magnitude difference, Δm, is found to be $0^m.07 \pm 0^m.01$. Spectra of the single-lined phase have been compared with those of similar stars to determine the spectral type (F5) and absolute magnitude (+4.0).

THE ORBIT

THE star H.D. 27483, $\alpha(1900) = 04^h15.2^m$, $\delta(1900) = +13°38'$, vis. mag. 6.14, type F2, was discovered to be a double-lined binary from four plates taken at the David Dunlap Observatory during 1935 and 1936.[1] Observation of the star was resumed in 1945, with a view to determining the spectroscopic orbital elements. Meanwhile it was observed at Mount Wilson Observatory and listed as a variable velocity star in a paper by William H. Christie and O. C. Wilson.[2] At the Dominion Astrophysical Observatory eighteen plates were taken from 1936 to 1938 by W. E. Harper and twenty-three plates from 1949 to 1951 by R. M. Petrie and K. O. Wright. Early in 1951 it was agreed to combine the radial-velocity measures made at the three observatories, the orbit to be computed at the David Dunlap Observatory and the determination of Δm to be done at the Dominion Astrophysical Observatory.

The observations consist of: (1) 41 plates from the Dominion Astrophysical Observatory, 34 taken with the IM dispersion of 30 A./mm. at Hγ, and 7 with the IS dispersion of 51 A./mm. at Hγ; (2) 41 plates from the David Dunlap Observatory, 35 taken with a dispersion of 33 A./mm. at Hγ, and 6 with a dispersion of 66 A./mm. at Hγ;(3) 6 plates from Mount Wilson Observatory with a dispersion of 38 A./mm. at Hγ. The six David Dunlap Observatory plates of lower dispersion were used in determining the period, but were not included in the least-squares solution. The observations near the V_0-axis, in which the velocities of the two components were not resolved, were not included in the solution. The

*Communications from the David Dunlap Observatory, No. 28. Contribution from the Dominion Astrophysical Observatory, No. 25.

[1] *P.D.D.O.*, vol. 1, no. 3, 1939.

[2] *Ap. J.*, vol. 88, p. 34, 1938.

TABLE I

OBSERVATIONS OF H. D. 27483

J.D. 242-243	V_o km./sec.		Obs.	Phase from final T	V_c km./sec.		$V_o - V_c$ km./sec.	
7378.921	− 27.5	+ 111.8	W	1.469	− 33.3	+ 108.3	+ 5.8	+ 3.5
7380.828	+ 87.8	− 14.9	W	0.317	+ 80.6	− 10.1	+ 7.2	− 4.8
7443.764	+ 36.9		W	2.071				
8082.876	− 16.8	+ 80.6	D	1.829	− 10.3	+ 84.4	− 6.5	− 3.8
8237.687	+ 22.6		V	0.625				
8241.655	− 29.4	+ 116.9	V	1.534	− 31.6	+ 106.5	+ 2.2	+ 10.4
8412.903	− 42.6	+ 122.5	D	1.472				
8430.878	− 25.5	+ 97.9	D	1.092	− 20.0	+ 94.5	− 5.5	+ 3.4
8484.699	+ 106.7	− 36.7	D	2.908	+ 108.1	− 38.7	− 1.4	+ 2.0
8510.810	− 37.5	+ 101.7	V	1.488	− 32.9	+ 107.9	− 4.6	− 6.2
8539.781	+ 105.0	− 33.2	V	2.927	+ 108.2	− 38.8	− 3.2	+ 5.6
8545.735	+ 102.7	− 36.0	V	2.762	+ 103.0	− 33.4	− 0.3	− 2.6
8545.830	+ 111.2	− 40.8	V	2.857	+ 107.0	− 37.6	+ 4.2	− 3.2
8552.813	+ 34.4		V	0.663				
8559.649	− 37.0	+ 101.1	V	1.381	− 33.7	+ 108.7	− 3.3	− 7.6
8608.686	− 32.4	+ 111.9	V	1.472	− 33.2	+ 108.2	+ 0.8	+ 3.7
8794.006	+ 113.0	− 25.8	V	0.186	+ 94.4	− 24.4	+ 18.6	− 1.4
8794.986	− 23.6	+ 101.2	V	1.166	− 25.7	+ 100.4	+ 2.1	+ 0.8
8804.973	+ 41.7		V	1.976				
8814.944	+ 108.5	− 32.4	V	2.770	+ 103.4	− 33.9	+ 5.1	+ 1.5
8816.938	− 18.6	+ 96.2	V	1.705	− 21.8	+ 96.3	+ 3.2	− 0.1
8828.892	− 32.1	+ 107.6	W	1.422	− 33.8	+ 108.8	+ 1.7	− 0.8
8828.908	− 37.4	+ 108.2	V	1.438	− 33.6	+ 108.7	− 3.8	− 0.5
8867.842	+ 33.6		V	0.604				
8902.795	− 12.6	+ 79.1	V	1.906	− 1.6	+ 75.4	− 11.0	+ 3.7
8965.640	+ 37.5		V	0.510				
9983.788	+ 103.3	− 40.6	W	3.034	+ 107.0	− 37.6	− 3.7	− 3.0
9984.757	− 7.6	+ 82.8	W	0.944	− 5.2	+ 79.2	− 2.4	+ 3.6
1702.904	+ 109.2	− 33.2	D	2.930	+ 108.2	− 38.9	+ 1.0	+ 5.7
1705.888	+ 105.4	− 33.6	D	2.855	+ 107.0	− 37.5	− 1.6	+ 3.9
1706.897	+ 33.8		D	0.805				
1708.872	+ 99.8	− 32.7	D	2.780	+ 104.0	− 34.4	− 4.2	+ 1.7
1728.856	− 33.5	+ 108.5	D	1.350	− 33.3	+ 108.4	− 0.2	+ 0.1
1770.745	+ 61.7	+ 0.9	D	0.411	+ 68.8	+ 2.2	− 7.1	− 1.3
1782.716	+ 96.7	− 29.8	D	0.146	+ 97.8	− 27.9	− 1.1	− 1.9
1790.664	+ 30.9		D	1.976				
1795.686	− 5.4	+ 68.3	D	0.879	+ 2.5	+ 71.1	− 7.9	− 2.8
1808.656	− 26.4	+ 103.4	D	1.613	− 27.9	+ 102.7	+ 1.5	+ 0.7
1813.670	+ 36.1		D	0.509				
1822.626	+ 84.5	− 14.2	D	0.287	+ 84.2	− 13.8	+ 0.3	− 0.4
1837.610	+ 102.0	− 36.5	D	3.035	+ 107.0	− 37.6	− 5.0	+ 1.1
1862.544	+ 59.4	+ 18.3	D	0.437	+ 65.3	+ 05.9	− 5.9	+ 12.4
2078.930	+ 102.6	− 29.7	D	2.685	+ 97.8	− 28.0	+ 4.8	− 1.7
2082.914	+ 37.0		D	0.551				
2090.896	+ 71.8	+ 3.5	D	2.415	+ 68.7	+ 2.2	+ 3.1	+ 1.3
2091.893	+ 75.3	− 0.8	D	0.353	+ 76.3	− 5.6	− 1.0	+ 4.8
2097.889	+ 94.0	− 21.4	D	0.231	+ 90.1	− 20.0	+ 3.9	− 1.4
2470.869	+ 104.2	− 36.6	D	3.058	+ 106.3	− 36.8	− 2.1	+ 0.2
2471.855	− 5.7	+ 85.4	D	0.985	− 9.8	+ 83.9	+ 4.1	+ 1.5
2473.840	+ 102.4	− 34.5	D	2.970	+ 108.2	− 38.8	− 5.8	+ 4.3
2474.744	+ 35.9		D	0.815				
2474.926	− 25.6	+ 85.4	D	0.997	− 11.1	+ 85.2	− 14.5	+ 0.2
2475.749	− 15.2	+ 90.9	D	1.820	− 11.2	+ 85.4	− 4.0	+ 5.5
2478.783	− 11.9	+ 93.3	D	1.795	− 13.7	+ 88.0	+ 1.8	+ 5.3
2479.760	+ 103.4	− 36.3	D	2.772	+ 103.6	− 34.0	− 0.2	− 2.3
2480.783	+ 37.3		D	0.736				

TABLE I—*Continued*

OBSERVATIONS OF H. D. 27483

J.D. 242-243	V_o km./sec.		Obs.	Phase from final T	V_c km./sec.		V_o-V_c km./sec.	
2481.823	− 12.9	+ 101.7	D	1.776	− 15.6	+ 89.9	+ 2.7	+ 11.8
2482.776	+ 99.7	− 30.0	D	2.729	+ 101.0	− 31.3	− 1.3	+ 1.3
2483.821	+ 40.8		D	0.715				
2486.744	+ 38.5		D	0.579				
2490.767	− 33.0	+ 93.3	D	1.542				
2536.660	− 24.7	+ 80.8	D	1.549				
2543.538	+ 34.1		D	2.309				
2815.851	+ 70.1	+ 4.0	D	2.361				
2817.894	− 24.8	+ 107.8	D	1.345				
3198.014	+ 38.3		V	2.135				
3199.918	− 14.9	+ 90.9	V	0.980	− 9.2	+ 83.3	− 5.7	+ 7.6
3219.942	+ 95.2	− 18.6	V	2.649	+ 94.8	− 24.8	+ 0.4	+ 6.2
3225.935	+ 88.9	− 18.8	V	2.524	+ 82.1	− 11.7	+ 6.8	− 7.1
3253.796	+ 103.0	− 35.3	V	2.853	+ 106.9	− 37.5	− 3.9	+ 2.2
3256.802	+ 96.3	− 27.3	V	2.800	+ 104.9	− 35.4	− 8.6	+ 8.1
3260.790	+ 33.0		V	0.670				
3261.793	− 21.6	+ 98.4	V	1.673	− 24.2	+ 98.8	+ 2.6	− 0.4
3315.790	+ 41.8		V	0.606				
3329.714	+ 41.5		V	2.293				
3339.666	+ 114.1	− 36.8	V	0.009	+ 105.9	− 36.4	+ 8.2	− 0.4
3351.640	+ 98.9	− 29.8	V	2.806	+ 105.2	− 35.7	− 6.3	+ 5.9
3371.651	− 34.2	+ 104.2	V	1.403	− 33.8	+ 108.8	− 0.4	− 4.6
3555.027	− 27.9	+ 104.6	V	1.232	− 29.5	+ 104.3	+ 1.6	+ 0.3
3555.901	+ 36.0		V	2.106				
3556.035	+ 39.1		V	2.240				
3556.911	+ 102.4	− 28.8	V	0.057	+ 103.7	− 34.1	− 1.2	+ 5.3
3563.848	+ 2.9	+ 70.9	V	0.876	+ 3.0	+ 70.5	− 0.1	+ 0.4
3597.806	− 22.5	+ 111.2	V	1.184	− 26.8	+ 101.6	+ 4.3	+ 9.6
3597.849	− 26.2	+ 107.4	V	1.227	− 29.2	+ 104.1	+ 3.0	+ 3.3
3597.928	− 26.6	+ 112.2	V	1.306	− 32.3	+ 107.3	+ 5.7	+ 4.9
3598.022	− 28.1	+ 112.4	V	1.400	− 33.8	+ 108.8	+ 5.7	+ 3.6
3653.726	− 7.4	+ 71.3	V	2.040	+ 15.6	+ 57.4	− 23.0	+ 13.9

data from the plates are given in Table I, where V_o is the measured radial velocity and V_c is the radial velocity computed from the final orbital elements. W, D and V refer to Mount Wilson, David Dunlap and Victoria; the velocities listed, V_o, have been obtained at the respective observatories. The omissions in columns 5 and 6 occur for those plates which were not included in the least-squares solution.

Since the observations come from three observatories they may include systematic errors characteristic of velocity measures at these observatories. In order to eliminate effects of these errors from the solution and at the same time to obtain values of the systematic differences, the following procedure was used. Two additional variables were used in the least-squares solution, one to "correct" the Victoria observations to David Dunlap, the other to "correct" the Mount Wilson observations to David Dunlap. Although the sampling is small for deriving systematic

differences in velocity between observatories, it seemed worth while to take account of the differences in this way. The observations were grouped independently by observatories into 38 observational equations: 18 from Victoria, 16 from David Dunlap, and 4 from Mount Wilson. Weights were assigned according to the number of plates and, in the case of the Victoria observations, according to dispersion as well.

The period of 3.059 days determined from the observations was verified by application of the test of R. W. Tanner for a fictitious period.[3] The period was not included in the solution. Preliminary elements were derived using R. K. Young's graphical method. A circular orbit fitted the observations reasonably well. Final elements were derived using T. E. Sterne's form of least-squares solution for very small eccentricities,[4] by which Σpv^2 was reduced by 28%. Table II gives the preliminary and final elements obtained. The individual observations are shown in figure 1. The probable error of a plate of average weight is 3.0 km./sec.

TABLE II

ORBITAL ELEMENTS FOR H. D. 27483

		Preliminary	Final	
Period	P	$3.^d05911$	$3.^d05911$	
Eccentricity	e	0	0.017	± 0.006
Angle of periastron	ω		193°.8	± 27°.1
Velocity of system	V_0	+ 37.0 km./sec.	+ 36.13	± 0.40
Epoch of mean longitude	T_0	J.D. 2431704.449	2431704.44	± 0.003
Date of periastron	T		2431706.09	
Semi-amplitude, primary	K_1	68 km./sec.	71.03	± 0.55
Semi-amplitude, secondary	K_2	72 km./sec.	73.86	± 0.41
$a_1 \sin i$			2.988×10^6	
$a_2 \sin i$			3.107×10^6	
m_1/m_2			1.040	
$(m_1 + m_2) \sin^3 i$			0.966 ⊙	
Victoria velocity difference			− 1.08 km./sec.	± 1.01
Mount Wilson velocity difference			− 0.67 km./sec.	± 0.59

It is interesting to note that the "corrections" for the Victoria and Mount Wilson velocities of -1.08 ± 1.01 and -0.67 ± 0.59 km./sec., respectively, have probable errors which are nearly as large as the corrections. Thus, within the probable errors involved, the velocities from the three observatories are in agreement. The Victoria spectrograms were measured employing the revised wave-lengths for F–K stars adopted by R. M. Petrie.[5] In a separate investigation,[6] Wright found that radial-velocity measures based on these revised wave-lengths were systematically

[3] *Comm. D.D.O.*, no. 16, 1948.
[4] *Pr. Ac. Sc.*, Wash., vol. 27, p. 175, 1941.
[5] *J.R.A.S. Can.*, vol. 40, p. 325, 1946; *Contr. Dom. Ap. O.*, no. 4, 1946.
[6] *P. Dom. Ap. O.*, vol. 9, no. 3, 1951 (in press).

more negative by 0.9 km./sec. than the measures given by R. E. Wilson's *New General Catalogue*.[7]

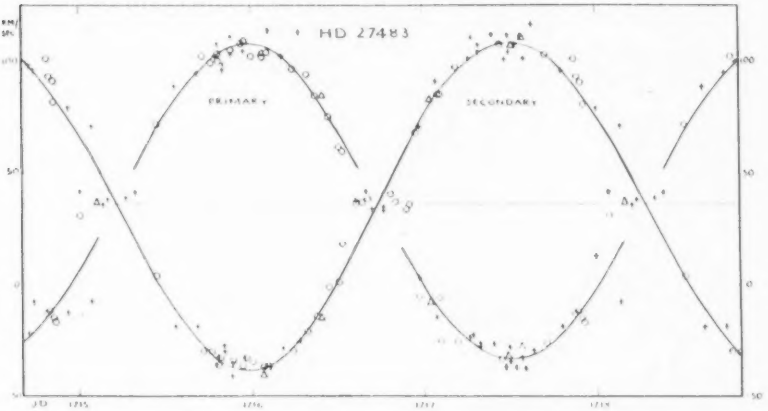


FIG. 1.—Velocity curves of the spectroscopic binary H.D. 27483. Observations from Mount Wilson are denoted by *triangles*, from Victoria by *crosses* and from David Dunlap by *circles*

DETERMINATION OF Δm

Spectra of H.D. 27483 observed at maximum separation show that the lines of the two components are nearly equal in strength. However, while searching for the period it had been found that primary and secondary components could be detected with fair certainty when plates taken at different phases were examined. Therefore it was decided to determine the ratio of the brightnesses l_1/l_2, and the difference in magnitude between the two components, Δm, from the intensities of their spectral lines.

R. M. Petrie[8] has recently published values of Δm for eighty-two spectroscopic binaries determined from measures of total absorption and line depths in the component spectra. Most of these systems consist of early-type spectra but he included seventeen F-, G-, and K-type spectra where the many lines present in each spectrum produce blending effects which make the measurement of Δm uncertain. The study of this system will illustrate a method of reducing the uncertainty in Δm by measuring the depths of the strongest lines in the spectrum and by allowing for the presence of lines of the second component at the same wave-length.

Intensity tracings of six well-exposed plates of the star (Victoria observations J.D. 3253.796, 3261.793, 3555.027, 3555.901, 3556.035 and

[7] *P. Carn. Inst.*, Washington (in press).
[8] *P. Dom. Ap. O.*, vol. 8, p. 341, 1950.

3556.911) were made covering the region λλ4000–4415. The two single-lined spectra were chosen as close to the V_o-axis as possible and, assuming that the spectral types of the components were very nearly the same, were taken to represent the spectrum of the single star. These tracings were made on an intensity scale half that of the double-lined spectra and, since the background had been rectified to place the continuous spectrum at an intensity level of 100 per cent. throughout the spectrum, the two tracings could be superposed. A smooth curve drawn through the random deflections produced by grains of the plate was taken to represent the spectrum of the single star. To a first approximation the spectra of the two components may be considered equal. Therefore two copies of the smoothed single-lined spectrum were made. They were superposed in turn on each of the tracings showing double lines, with the single spectra displaced relative to each other by an amount equal to the velocity displacement listed in Table I. Thus at the displaced wave-length of each line the depth of the line in the double-lined phase, the depth in the single-lined phase, and the depth of any line in the second star displaced by an amount equal to the velocity difference between the components, could be measured.

The method is illustrated in figure 2 where spectra of double- and single-lined phases are shown for the region λλ4035–4140 and, on the same scale, intensity tracings of the same spectra. These tracings include: (*a*) the double-lined phase; (*b*) the single-lined spectrum displaced to make the lines correspond to the position of the blue components of the double-lined phase; and (*c*) the single-lined spectrum displaced to correspond to the red components of the double-lined phase. If the components were equal in intensity and if the continuous background had been drawn correctly in each case, then for any wave-length the line depth for the double-lined phase should equal the sum of the depths for the two single spectra (since the latter were drawn on one-half the intensity scale). Actually the components are not precisely equal; therefore if measurements of numerous lines are made throughout the spectrum and the depths from the single-lined tracings are multiplied by constant factors, x for the bright component and y for the faint component, then a correction to the initial assumption of equality in the components can be made. As an example taken from the work sheets, if the red component, tracing (*c*), is multiplied by x and the blue component, tracing (*b*), is multiplied by y, then for the line λ4078 we have

$$\text{blue component: } 9.3x + 21.1y = 31.3$$
$$\text{red component: } 21.1x + 14.6y = 33.2,$$

where the numbers are percentages of the continuous background on the scale of the double-lined tracing. Similar equations for twenty lines

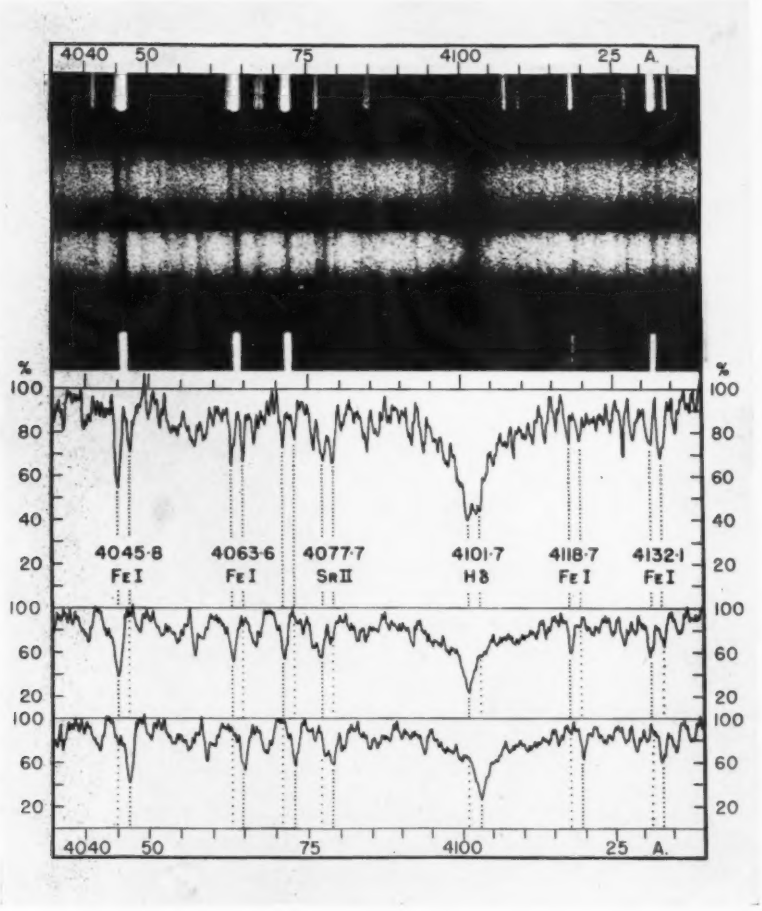


FIG. 2.—Spectra and intensity tracings of H.D. 27483 in the region λλ4035–4140.

The top spectrum and top tracing correspond to phase $1^d.232$ when the spectral lines of the two stars were widely separated. The lower sections correspond to phase $2^d.106$ when the lines were superposed. The tracings of the single phase have been displaced so that the position of each single spectral line agrees with the position of the corresponding component at the double phase. The dotted vertical lines have been drawn to indicate positions in the spectrum at which measurements were made, as described in the text, to determine the relative luminosities of the two components. The magnification is 44× the original plate.

TABLE III

DETERMINATION OF Δm

Victoria Observation	Phase	x	y	I_1/I_2	Bright Component
J.D.	days				
3253.796	2.853	1.128	1.001	1.127 ± 0.029	Red
3261.793	1.673	1.083	1.025	1.057 ± 0.036	Violet
3555.027	1.232	1.022	0.965	1.059 ± 0.026	Violet
3556.911	0.057	1.168	1.134	1.029 ± 0.027	Red
	Mean			1.067 ± 0.014	
	Δm			0.07 ± 0.01	

were set up for each plate and least-squares solutions were made to determine x and y and their probable errors. These values and the ratio x/y and its probable error are given in Table III. It is found that there is a real difference in the intensity of the two components and that the results agree with the phases found from the velocity curve. Thus we may say that this method of determining the relative brightnesses of the components of a spectroscopic binary, though somewhat laborious, gives quite satisfactory results. The present case is relatively favourable for the method since no differences in the spectra of the two components could be detected; if they had been markedly different the spectrum at the V_0-axis could not have been assumed to represent that of each component and considerably greater errors would have resulted. The probable errors in this case are as small as could be expected. They may be compared with those given by Petrie in his extended study.[8] For F- to K-type spectra his average error in Δm is ± 0.04 but this value includes unfavourable cases and further, relatively few lines were measured for each star. He estimates that his methods should give a probable error in Δm of about 0.03 for the type of spectrum studied here.

THE PHYSICAL CHARACTERISTICS OF THE SYSTEM

To complete the present study of these stars the spectra at the single phase were examined and compared with stars of similar type and absolute magnitude studied by Young and Harper.[9] The spectrum was classified as F2 in the Henry Draper Catalogue and by the Mount Wilson observers;[10] the latter estimated the absolute magnitude to be + 3.0, but indicated the presence of double lines. The present plates should permit a more accurate estimate. Details concerning the classification of stellar spectra have been given in a previous number of the JOURNAL.[11] Since the spectrum is approximately F5 in type and that of a dwarfish star, it was

[8] *P. Dom. Ap. O.*, vol. 3, no. 1, 1924.
[9] Adams, W. S., A. H. Joy, et al., *Ap. J.*, vol. 81, p. 187, 1935.
[11] *J.R.A.S. Can.*, vol. 44, p. 129, 1950.

compared with thirty-five stars of classes F4 to F6 and absolute magnitudes $+2$ to $+5$. The spectral type was determined principally from the ratio $\lambda 4227$, CaI to $\lambda 4340$, Hγ. The absolute magnitude criteria were the line-ratios $\lambda\lambda 4072$ to 4078, 4216 to 4250, 4247 to 4251, 4258 to 4260, and 4162 to 4168. Independent eye estimates of these ratios were made for each star and the final values for H.D. 24783 (F5, $+4.^{m}0$) were obtained from smooth curves drawn from plots of these eye estimates.

TABLE IV

PHYSICAL CHARACTERISTICS OF THE SYSTEM H.D. 27483

		Primary	Secondary
Spectrum		F5	F5
Magnitude	m_v	6.86	6.93
Absolute Magnitude	M_v	4.0	4.1
Effective Temperature	T_e	6470 °K.	6470 °K.
Bolometric Magnitude	M_b	4.1	4.2
Mass	m	0.97 $\odot$	0.93 $\odot$
Radius	R	0.71 $\odot$	0.68 $\odot$
Density	ρ	2.7 $\odot$	3.0 $\odot$
Orbital Radius	a	3.95×10^6 km.	3.80×10^6 km.
Inclination of Orbit	i	51°	

The physical characteristics of the system are given in Table IV. The effective temperature is Kuiper's value[12] for F5 stars and the mass was obtained from Petrie's mass-luminosity diagram.[13] The theoretical relation between absolute magnitude, radius and temperature is, as given by Russell, Dugan and Stewart,[14]

$$M_v = -0.24 - 5 \log R + \frac{28400}{T}.$$

The inclination of the orbit (51°) was found by comparing the value of $m \sin^3 i$ obtained from the solution for the radial-velocity orbit with the mass determined from the absolute magnitude and was used in estimating the radius of the orbit, a. These data indicate that the system is quite normal although according to the Russell diagram the luminosities are somewhat lower than the average for the spectral type.

David Dunlap Observatory
Richmond Hill, Ont.

Dominion Astrophysical Observatory
Victoria, B.C.
December 1951

[12] *Ap. J.*, vol. 88, p. 429, 1938.
[13] *P. Dom. Ap. O.*, vol. 8, p. 341, 1950.
[14] *Astronomy*, vol. 2, p. 732, 1938 (Ginn and Co., Boston).

EIGHTY-SIXTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY

By J. F. Heard

Accepting the invitation of Dr. J. J. Nassau, director of the Warner and Swasey Observatory of the Case Institute of Technology, the American Astronomical Society held its winter meeting at that Institute in East Cleveland, Ohio, December 26–29, 1951. A large number of astronomers from all parts of the United States and a representation from Canada were in attendance. The arrangements made for the guests by the Case Institute were excellent, the splendid accommodation and meals contributing a good deal to the success of the meeting.

In six sessions approximately 80 papers were presented covering every branch of astronomy. Four of these were from Canadian observatories: "An Oscilloscopic Microphotometer and Plate Measuring Machine," by William R. Hossack, David Dunlap Observatory; "Variable Stars in the Globular Cluster NGC 6838," by Helen Sawyer Hogg, David Dunlap Observatory; "The Chromospheric K-line during the Recent Eclipse of 31 Cygni," by Andrew McKellar, G. J. Odgers (Dominion Astrophysical Observatory) and L. H. Aller; "The Spectrographic Orbit of the A-type Eclipsing Variable H.D. 190786, V477 Cygni," by Joseph A. Pearce, Dominion Astrophysical Observatory.

It is always of particular interest to astronomers when a scientist from some other branch enters their field. One of the papers on the programme was of this nature. Harold C. Urey, renowned chemist and Nobel Prize winner of the University of Chicago, presented a paper on the surface of the moon, a subject which he believes is too much neglected by astronomers. Urey presented visual evidence and computations which have led him to the view that some of the lunar seas were formed by the melting of large iron meteorites which had been lobbed onto the surface of the moon with relatively low velocities and in directions nearly parallel to the moon's surface. This came to Urey as an extension of Ralph B. Baldwin's views on the origin of Mare Imbrium.*

The moon came in for discussion from quite another angle in a series of papers by John A. O'Keefe and others of the United States Army Map Service. These researchers have been much concerned recently with the precise timing of lunar occultations for the purposes of measuring distances on the surface of the earth and so resolving some

*_The Face of the Moon_, by Ralph B. Baldwin, 1949.

of the outstanding uncertainties regarding the earth's size and shape. It is an impressive thing that observations of the "inconstant" moon are being looked to for information regarding the planet under our feet.

On the evening of December 30 members heard Dr. Jan H. Oort of the Leiden Observatory, Holland, deliver the Russell Lecture on the subject, "Problems of Galactic Structure." Oort is one of the greatest living astronomers, a recognized authority in problems of structure and motion of the galaxy. In his lecture he reviewed the state of our present knowledge of the galaxy and stressed particularly the contributions which had been made and would be made by the observations of radio astronomy. He ventured the opinion that we are now entering a stage where we must look to radio for as much or more information than we can obtain from further light observations.

One session was devoted to a symposium on the Hertzsprung-Russell Diagram, the important relation that exists between the luminosities of stars and their colours, and which, more than anything else, points the way in which stars are born, develop and die. Not that the way is yet clearly indicated, as was apparent from listening to the views of such astronomers as Dr. Martin Schwarzschild of Princeton and Dr. Bengt Stromgren of Yerkes. But some facts appear to be emerging with increasing clarity, for example, that over periods of time changes take place in the chemical constitution of the stars—poorness in hydrogen and richness in carbon seem to go together as a symptom of old age in a star.

One of the papers in the symposium drew the comment from the chairman that it was one of the most important read to the Society in recent years. This was a report by Dr. W. W. Morgan of Yerkes of an investigation by himself and some of his colleagues which seemed to indicate clearly a pattern of spiral arms in our galaxy. The sun, it seems, is between two arms and the arms are trailing. Perhaps this is the final answer to the question which for years has been such a contentious issue: in a galaxy do the arms trail or lead?

No less important than the astronomical feast at a meeting of the A.A.S., is, to quote an old quip, the gastronomical. So, following custom, Friday evening was devoted to the Society Dinner which took place in Tomlinson Hall, the fine students' union of the Case Institute. Among the speakers were the President of the Society, Professor Alfred H. Joy of Mount Wilson and Palomar, President Glennon of the Case Institute, Dr. Oort of Leiden, and Dr. Bart J. Bok of Harvard.

The last day of the meeting included a visit to the Warner and Swasey Observatory where so much fine work has been done by Dr. Nassau and his colleagues with the 36-inch Schmidt telescope.

H. C. SCHUMACHER AND THE OBSERVATORY AT ALTONA*

By W. Voss

The old observatory at Altona, with its remarkable gables, and starry emblems to the left and right of the first story windows, was among the buildings destroyed by aerial bombardment in the late war. The two buildings of the observatory, facing on the Palmaille and the Smissens-Allee, were constructed in 1821 by King Frederick VI of Denmark and Herzog Von Holstein for the astronomer H. C. Schumacher. This many sided man and his observatory became the centre for the work of the *Astronomische Nachrichten*.

The instruments were placed in the observatory grounds. A meridian circle by Reichenbach, modified by Repsold, with a telescope 10 centimetres in aperture and with a focal length of 1.5 metres, was set up in the centre of the gardens, while a zenith sector, loaned by the English Crown, was placed near the southern building. This building provided valuable working space. Before this (in 1811) the instruments had been removed from Repsold's private observatory to the Albertus Bastion at Stintfang because of the French invasion. The first State Observatory was founded in 1827 at Holstenwall, where now stands the Historical Museum of Hamburg.

In 1821 Mösting, the Danish Finance Minister, suggested that Schumacher should edit a publication of astronomical news. Schumacher seized the opportunity, and the first number of the famous *Astronomische Nachrichten* appeared in September of the same year. As Schumacher had a wide circle of correspondents and acquaintances the publication quickly achieved world-wide circulation. Bessel, Gauss, Repsold and others were his intimate friends.

Schumacher began studies of the pendulum with Bessel and Repsold in 1825. The first measures were made in the cellar of the observatory. Out of this came a revision of the Danish system of weights as well as geomagnetic observations. They also began numerous and valuable chronometric comparisons to determine the difference in longitude between Altona, Greenwich, Copenhagen, Pulkovo, and other places. The first determination was made by Schumacher himself. This work required some 86 ship's chronometers. Carrying these sensitive timepieces great distances over the roads of that time must have been very difficult.

*From *Sternewelt*, July-August 1951. Translated by R. L. Baglow.

The year 1848 brought many political disturbances. Schumacher was now Professor of Astronomy at Copenhagen, and only came to Altona when working on the topographical survey. The observatory was the astronomical centre for the so-called Danish arc from Skagen to Laverburg. Schumacher liked to move about now and then rather than remain at home. He died at the age of 70 on 28 December, 1850 after a serious illness. He lies buried about a hundred yards from his house in the old church-yard on the Behnstrasse. His gravestone is still to be seen. The low pyramid of syenite was overthrown by a bomb, but has been restored to its position by the state, and the inscription renewed.

Schumacher had a rather slight build, with a weak constitution and poor health. A distinguished man himself, he delighted in working with his equals. His greatest joy was in the far reaching researches of his friends Gauss and Bessel. The sudden death of Repsold through an accident at a fire while he was carrying out his duties as fire chief touched him deeply. He was still more bereft when Bessel died in 1846. Of his many old friends only Gauss remained. The city of Altona has named a street in honour of Schumacher. An old notice in a newspaper says that a statue of Schumacher was to be placed on the corner house of the street. This was not carried out, but a medallion was placed there, which is not now to be seen. A group of friends of astronomy continued to use the old building for almost thirty years. Many relics of Schumacher's time remain. In a panelled upper room are many cupboards and drawers which served to store small instruments such as glasses, sextants, transits, theodolites, magnetic instruments and the like. The three windows of the large workroom open to the south and give a delightful view of the Elbe and its banks. There is a large balcony, supported by four slender iron columns, but it is not firm enough to allow the use of instruments for observation.

One of Schumacher's grandchildren still lived in Altona in 1920. He did not know very much about his grandfather: "He was a state official of ministerial rank, and on important occasions wore a fine uniform." There are still a few descendants in the town.

In its 70th year the Altona Observatory was abolished. The publication of the *Astronomische Nachrichten* then went to Kiel, where it remained till 1939. It was then removed to Berlin.

REVIEW OF PUBLICATIONS

The Heavens Are Telling, by Urana Clarke. 128 pages; 9 x 6 in. Acorn House, 1951. Price $2.95.

"We can be a little curious about astronomy," says the author, ". . . and we can be extremely curious." Young folk, she knows, are rarely "a little curious" about anything. They ask innumerable questions and want definite answers. In this respect *The Heavens Are Telling* is a very satisfying sort of book. Each chapter title is a question, concisely answered in the opening sentence and then dealt with in more detail. Miss Clarke, however, does not expect her readers to be content simply with being told. Eager to share her own love of watching the sky, she has included some sound practical advice to young star-gazers that will encourage them to go outdoors and discover things for themselves.

Written in a delightfully informal style but in adult language, this is a book to be recommended to the "in-between" group that feels too grown up for most children's books and sometimes gets confused by tackling more technical works too soon. It is also an excellent introduction for adults with a newly acquired interest in astronomy.

I. K. WILLIAMSON

L'Astrologie, by Paul Couderc. Pages 127; 4½ x 7 in. Paper bound. Paris, Presses Universitaires de France, 108 Boulevard Saint-Germain, 1951.

Among astronomers there is a standing joke about astrology, the pseudo-science which deals with horoscopes and the alleged influence of the heavenly bodies upon human affairs. Astronomers, who often regard themselves as underpaid, sometimes threaten to turn their knowledge to account in the casting of horoscopes for fat fees. Indeed, when we hear of the fabulous earnings of some of the modern proponents of this ancient hocus-pocus, it is a little tempting, to tell the truth. Unfortunately few astronomers have any knowledge of the jargon and the supposed rules of the subject, and, in fact, it is hard to find a systematic and connected account of the subject. So this little book in French will be welcomed not only by the desperate astronomers bent on turning a dishonest penny, but also by those, astronomers and others, who would like a clear account of the subject of astrology by one who is not committed to prejudice in its favour. The author, Paul Couderc, is no astrologer; he is an astronomer at the Paris Observatory who has had wide experience as a writer of popular books on astronomy.

In Chapter 1 Couderc gives a brief review of astronomy—the constellations, the nature of the sun, moon, planets, stars, and the laws that govern their motions. In Chapter 2 he explains, without comment, the several branches of astrology, the terms most frequently used, the associations that are said to exist such as those between the planets and human traits, etc. With this preparation, the author then discusses in Chapter 3 the value of astrology. He concludes, as one might expect, that it has "exactly none," and he states with some satisfaction that there is *not one* astronomer in the world who believes in astrology. That there were in the past, is true, but, says the author, the progress of science has now convinced astronomers of the falsity of astrological doctrine. But Couderc does not merely rest his case on the unanimity of astronomical opinion; he answers the arguments of the modern astrologers one by one, he shows the absurdity of the manner in which they seize upon modern astronomical discoveries and try to fit them into the ancient superstition, he quotes surveys that have been made of the birthdays of musicians and of scientists disproving the supposed connections of their dates with their talents, he demonstrates by the laws of statistics that chance accounts for what apparent successes astrologers enjoy.

In Chapter 4 Couderc gives us a fascinating résumé of the part played by astrology in history. He debunks many of the myths that have apparently been foisted upon us by the astrologers; the myth of the church's support of astrology, the myth of Nostradamus' successful prophecies, the myth of Kepler's belief in astrology (poor Kepler was forced into the business by dire poverty).

Finally in Chapter 5 Couderc lets go with both barrels at present day astrology. Bad though it is in France (despite laws against it), it is worse in the United States. According to a survey in 1943, five million Americans spent 200 million dollars annually on horoscopes and the like. The newspapers, either through venality or ignorance, contribute to this scandalous situation by publishing horoscopes. The people who are preyed upon are those who have no contact with true science, and who are more easily swayed by emotional than by rational approach. It is the duty of all astronomers, professional and amateur, to expose astrology for what it is, a delusion and an absurd pseudo-science. It is the duty further of educators, learned societies, and UNESCO to unite in reaction against the progress of astrology by effective legal measures. Laws, which presently exist in most countries to protect the public against the fraudulent practice of astrology, are apparently ineffective.

In Canada we are not immune from the scandal of this particular

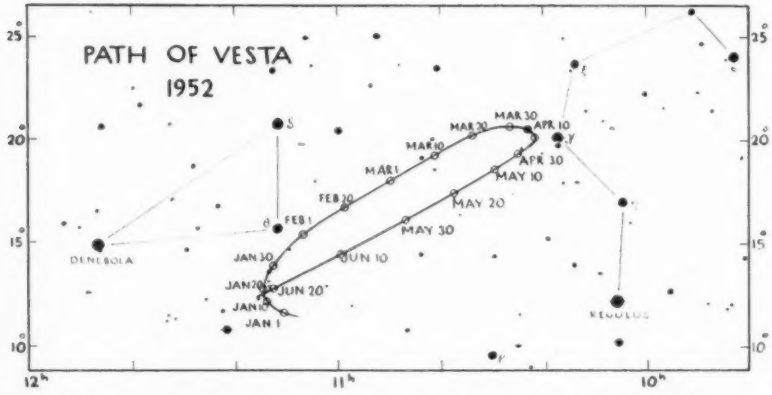
brand of charlatanism, as witness the columns that appear in our newspapers. Perhaps we who hold the key should be less complacent about the situation. This reviewer would like to see an English translation of Couderc's splendid little book as a beginning of a campaign to protect the public against those who would, in these enlightened days, keep alive an ancient hoax for their own wicked ends.

J. F. H.

NOTES AND QUERIES

Vesta

Vesta, the brightest of all asteroids, may be observed in the constellation Leo during the next few months. It will be in opposition to the sun on March 1, when its magnitude will be 6.5. Thus the asteroid is too faint to be seen with the naked eye, but is readily seen with binoculars or a small telescope. The accompanying chart shows its path in Leo.



The diameter of Vesta is estimated to be about 240 miles. Through the largest telescopes experienced observers can detect that it has a tiny disk. The light from Vesta is similar to the light from the moon, and is reflected sunlight. Vesta presents an intriguing problem, for its brightness may vary by about 0.15 of a magnitude in a few hours. One interpretation of this is that Vesta is irregular in shape and is rotating

rapidly. However, the variations in brightness are highly irregular, so that no period has been found.

Vesta was discovered in 1807, the fourth asteroid to be found. At this time the search for asteroids was entirely visual, by comparing the sky with a chart of the region. Photography has greatly speeded up this work, and now over 1,500 asteroids are known.

R. J. N.

Work at Radcliffe Observatory

The Radcliffe Observatory at Pretoria, South Africa, has a 74-inch telescope which is a sister to that at the David Dunlap Observatory. These telescopes were both made by Grubb-Parsons in England. The Radcliffe telescope was put into operation towards the end of 1948, and was used only at the Newtonian focus. The Cassegrain mirror and the Cassegrain spectrograph were being installed during 1951, and with this apparatus a programme of radial velocities of southern stars will be inaugurated. This programme will be the southern counterpart of the work at David Dunlap. The work at the Newtonian focus includes a survey of southern planetary nebulae, a study of elliptical nebulae by photographic photometry, variable stars and a study of the radial velocities of globular clusters with a Newtonian spectrograph.

C. A. C.

Chubb Crater, Ungava

Evidence of the continued interest in this crater in Canada's northland lies in a number of articles printed about the crater in recent months. An account of the crater as seen from the air is given in the January 1952 issue of *Sky and Telescope*. The first Royal Ontario Museum expedition in the summer of 1950 is described by Robert C. Hermes, the photographer of the expedition, in the November–December 1951 issue of *Canadian Nature*. A second expedition, sponsored jointly by the Royal Ontario Museum and the National Geographic Society was made in July and August 1951. A brief report of this is given in *Sky and Telescope*, November 1951, and a complete report by Dr. V. Ben Meen, leader of the expedition, is given in the *National Geographic Magazine*, January 1952. The crater was surveyed and found to be 11,500 feet from rim to rim, with the lake having a diameter of 9,100 feet and a maximum depth of 825 feet. Mine detectors were found to be useless in the search for meteoric material and results with power magnets dragged over the ground were inconclusive. Just 48 hours before leaving a magnetic anomaly along the eastern part of the rim was

detected using magnetometers. This could be interpreted as being due to the presence of an underground mass of metal, and might be buried portions of a meteorite.

R. J. N.

ROBERT GRANT AITKEN, 1864–1951

Robert Grant Aitken was born at Jackson, Cal., Dec. 31, 1864 and died Oct. 29, 1951.

He was A.B. '87, A.M. '92, Sc.D. '17 from Williams College; honorary Sc.D. of University of Pacific '03, of Arizona '23, and LL.D. of California '35. He was Professor of Mathematics and Astronomy in the University of the Pacific 1891-95, and after spending a summer at the Lick Observatory in 1895 was Assistant Astronomer there 1895-1907 and Astronomer 1907-35, and then Emeritus. He was Associate Director 1923-30 and Director 1930-35 after which he became Emeritus.

Dr. Aitken spent much of his long life in observing double stars with the great 36-inch refractor, although his observations of faint satellites and comets are also well known. His book *The Binary Stars* appeared in 1918, being one of a series of publications to celebrate the semi-centennial of the University of California.

He was a member of many astronomical societies and he was awarded three gold medals—the Lalande Medal from the French Academy in 1906, the Bruce Medal from the Astronomical Society of the Pacific in 1926, and the Royal Astronomical Society Medal in 1932.

C. A. C.

ALFRED TENNYSON DELURY, 1864–1951

Alfred Tennyson DeLury was born at Manilla, a village near Lindsay, Ont., the son of Daniel and Catherine Weir DeLury. He was of Irish descent. He attended the high schools in Oshawa and Bowmanville, and passed the Matriculation examination in 1882. He taught in Manilla for some years and entered the University of Toronto in October 1886, enrolling in the course in Mathematics and Physics. He graduated with the highest distinction in the Mathematics division in 1890. During his course he took an active part in various student interests.

DeLury's first appointment after graduation was to a collegiate school which was being organized in Vancouver, B.C., but this project was not a success. Harbord Collegiate Institute in Toronto was just then being established and DeLury was called to be its Mathematical Master. This appointment was not held long. In 1892 some new positions were created on the staff of the University, and DeLury was chosen Lecturer in Mathematics, with duties beginning in October of that year. He became

Associate Professor in 1902 and was professor from 1908 until 1934, when he retired as Professor Emeritus. He was Dean of the Faculty of Arts 1922–1934. He was Dean of the University Residence 1892–1899, when it was discontinued. He was elected Senator of the University in 1904; first President of the University Athletic Association, and later its No. 1 Honorary Life Member; and was Captain of the U. of T. Rifle Association 1904–06.

DeLury was elected a member of the Royal Astronomical Society of Canada May 2, 1893, and was President 1910, 1911. He gave many addresses, including courses of elementary lectures. He was elected Fellow of the Royal Society of Canada 1919 and President of Sec. III 1925–26. He was a member of the American Mathematical Society. Also, he was a member of the Arts and Letters Club of Toronto.

After retiring in 1934 he gave much time to gardening, and largely through his efforts the greater part of a village block in Manilla was made into a public park.

Within a few days of his death on November 12, he made a handsome contribution to the fund being collected for a scholarship in Astronomy in the University in memory of Frank Scott Hogg.

DeLury was unmarried. He leaves three brothers: Daniel O'Connell (Walker, Minn.), Attorney and former member of the Minnesota Legislature; Ralph Emerson (Ottawa and Manilla), who was on the staff of the Dominion Observatory for 40 years; and Justin Sarsfield (Uxbridge) who was professor of Geology at the Universities of Idaho and Manitoba, and Geologist for the Manitoba Government for 25 years; and two sisters, Minnie (Ottawa), a former nurse, and Abigail (Manilla), formerly Head of the Extension in Home Economics, University of Saskatchewan.

C. A. C.

OUT OF OLD BOOKS

By Helen Sawyer Hogg

Galileo and the Surface of the Moon

During the past few years much progress has been made in the interpretation of the remarkable surface features of the moon. Long neglected, probably because of the lack of noticeable change in its surface, the moon once more has come into importance as a source of fruitful astronomical study and thought.

The appearance of the excellent book, *The Face of the Moon*, by Dr. Ralph B. Baldwin in 1949 has done a great deal to crystallize current thought on the origin of the lunar maria and craters. This book is a masterly discussion of the correlation of the various surface features of the moon. Baldwin shows that not only all the craters could have been caused by impact of meteorites, but that the large maria probably resulted from direct hits of large bodies. In particular, various grooves on the moon's surface, radiating outward from the centre of Mare Imbrium, indicate that this region of the moon was once the scene of a terrific explosion. This catastrophe not merely formed Mare Imbrium itself, with its surrounding high mountain ranges, but also touched off a flow of lava which spread over a large section of the lunar surface.

At the winter meeting of the American Astronomical Society held in December 1951 at the Case Institute of Technology in Cleveland, one of the most outstanding papers was presented by the well-known physicist and chemist, Dr. Harold C. Urey of the University of Chicago. Following the lines suggested by Baldwin, Dr. Urey computed the tensile strength of objects which, when hurled across the moon's surface with speed of a mile a second by the Mare Imbrium explosion, would be able to cut great grooves across the surface and plow chasms through the mountains. He found that these missiles needed to have a high tensile strength such as that of nickel iron, whereas the strength of the resisting lunar surface must be low, comparable to pumice.

Because of the revival of interest in the lunar surface, it is interesting to read the beginnings of the subject when Galileo began to study the lunar features with his first telescope. Long before the invention of the telescope, however, some of the early Greek philosophers had very lucid ideas of the moon's source of illumination and the ruggedness of its surface. In particular, Anaxagoras, born about 500 B.C., realized that the sun was responsible for the moon's light, as he declared

"The sun places the brightness in the moon." Further, he stated that "The moon is an incandescent solid, having in it plains, mountains, and ravines," and said also that "It has a surface in some places lofty, in others low, in others hollow." Only when telescopes became available, however, could the host of craters and other details of the lunar surface be properly seen.

An excellent translation of *The Sidereal Messenger* of Galileo Galilei, 1610, containing the original account of Galileo's first astronomical discoveries, was published in 1880 by E. S. Carlos of Christ's Hospital, England. We quote some excerpts from this work giving Galileo's first impressions of the moon. Some, but not all, of this has already been republished in the splendid *Source Book of Astronomy* by Shapley and Howarth, 1929.

From Galileo's *Sidereus Nuncius*, 1610

The Moon. Ruggedness of its Surface

Let me speak first of the surface of the Moon, which is turned towards us. For the sake of being understood more easily, I distinguish two parts in it, which I call respectively the brighter and the darker. The brighter part seems to surround and pervade the whole hemisphere; but the darker part, like a sort of cloud, discolours the Moon's surface and makes it appear covered with spots. Now these spots, as they are somewhat dark and of considerable size, are plain to every one, and every age has seen them, wherefore I shall call them *great* or *ancient* spots, to distinguish them from other spots, smaller in size, but so thickly scattered that they sprinkle the whole surface of the Moon, but especially the brighter portion of it. These spots have never been observed by any one before me; and from my observations of them, often repeated, I have been led to that opinion which I have expressed, namely, that I feel sure that the surface of the Moon is not perfectly smooth, free from inequalities and exactly spherical, as a large school of philosophers considers with regard to the Moon and the other heavenly bodies, but that, on the contrary, it is full of inequalities, uneven, full of hollows and protuberances, just like the surface of the Earth itself, which is varied everywhere by lofty mountains and deep valleys.

The appearances from which we may gather these conclusions are of the following nature:—On the fourth or fifth day after new-moon, when the moon presents itself to us with bright horns, the boundary which divides the part in shadow from the enlightened part does not extend continuously in an ellipse, as would happen in the case of a perfectly spherical body, but it is marked out by an irregular, uneven, and very wavy line, as represented in the figure given, for several bright excrescences, as they may be called, extend beyond the boundary of light and shadow into the dark part, and on the other hand pieces of shadow encroach upon the light:—nay, even a great quantity of small blackish spots, altogether separated from the dark part, sprinkle everywhere almost the whole space which is at the time flooded with the Sun's light, with the exception of that part alone which is occupied by the great and ancient spots. I have noticed that the small spots just mentioned have this common characteristic always and in every case, that they have the dark part towards the Sun's position, and on the side away from the Sun they have brighter

boundaries, as if they were crowned with shining summits. Now we have an appearance quite similar on the Earth about sunrise, when we behold the valleys, not yet flooded with light, but the mountains surrounding them on the side opposite to the Sun already ablaze with the splendour of his beams; and just as the shadows in the hollows of the Earth diminish in size as the Sun rises higher, so also these spots on the Moon lose their blackness as the illuminated part grows larger and larger. Again, not only are the boundaries of light and shadow in the Moon seen to be uneven and sinuous, but—and this produces still greater astonishment—there appear very many bright points within the darkened portion of the Moon, altogether divided and broken off from the illuminated tract, and separated from it by no inconsiderable interval, which, after a little while, gradually increase in size and brightness, and after an hour or two become joined on to the rest of the bright portion, now become somewhat larger; but in the meantime others, one here and another there, shooting up as if growing, are lighted up within the shaded portion, increase in size, and at last are linked on to the same luminous surface, now still more extended. . . . Now is it not the case on the Earth before sunrise, that while the level plain is still in shadow, the peaks of the most lofty mountains are illuminated by the Sun's rays? After a little while does not the light spread further, while the middle and larger parts of these mountains are becoming illuminated; and at length, when the Sun has risen, do not the illuminated parts of the plains and hills join together? The grandeur, however, of such prominences and depressions in the Moon seems to surpass both in magnitude and extent the ruggedness of the Earth's surface, as I shall hereafter show. . . .

This part of the surface of the Moon, where it is marked with spots like a peacock's tail with its azure eyes, is rendered like those glass vases which, through being plunged while still hot from the kiln into cold water, acquire a crackled and wavy surface, from which circumstance they are commonly called *frosted glasses*.

[Specimens of *frosted or crackled Venetian glass* are to be seen in the Slade Collection, British Museum, and fully justify Galileo's comparison.]

Then Galileo goes on to suggest that the lunar spots may be seas bordered by ranges of mountains. Modern ideas are that they are geological seas, but the material which filled them was lava, and not water, for water is completely absent from the surface of the moon at present.

Now the great spots of the Moon observed at the same time are not seen to be at all similarly broken, or full of depressions and prominences, but rather to be even and uniform; for only here and there some spaces, rather brighter than the rest, crop up; so that if any one wishes to revive the old opinion of the Pythagoreans, that the Moon is another Earth, so to say, the brighter portion may very fitly represent the surface of the land, and the darker the expanse of water. Indeed, I have never doubted that if the sphere of the Earth were seen from a distance, when flooded with the Sun's rays, that part of the surface which is land would present itself to view as brighter, and that which is water as darker in comparison. Moreover, the great spots in the Moon are seen to be more depressed than the brighter tracts; for in the Moon, both when crescent and when waning, on the boundary between the light and shadow, which projects in some places round the great spots, the adjacent regions are always brighter, as I have noticed in drawing my illustrations, and the edges of the spots referred to are not only more depressed than the brighter parts, but are more even, and are not broken by ridges or ruggednesses. . . .

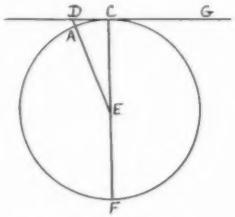
These phenomena which we have reviewed are observed in the bright tracts of the Moon. In the great spots we do not see such differences of depressions and prominences as we are compelled to recognise in the brighter parts, owing to the change of their shapes under different degrees of illumination by the Sun's rays according to the manifold variety of the Sun's position with regard to the Moon. Still, in the great spots there do exist some spaces rather less dark than the rest, as I have noted in the illustrations, but these spaces always have the same appearance, and the depth of their shadow is neither intensified nor diminished; they do appear indeed sometimes a little more shaded, sometimes a little less, but the change of colour is very slight, according as the Sun's rays fall upon them more or less obliquely; and besides, they are joined to the adjacent parts of the spots with a very gradual connection, so that their boundaries mingle and melt into the surrounding region. But it is quite different with the spots which occupy the brighter parts of the Moon's surface, for, just as if they were precipitous crags with numerous rugged and jagged peaks, they have well-defined boundaries through the sharp contrast of light and shade. Moreover, inside those great spots certain other tracts are seen brighter than the surrounding region, and some of them very bright indeed, but the appearance of these, as well as of the darker parts, is always the same; there is no change of shape or brightness or depth of shadow, so that it becomes a matter of certainty and beyond doubt that their appearance is owing to real dissimilarity of parts, and not to unevenness only in their configuration, changing in different ways the shadows of the same parts according to the variations of their illumination by the Sun, which really happens in the case of the other smaller spots occupying the brighter portion of the Moon, for day by day they change, increase, decrease, or disappear, inasmuch as they derive their origin only from the shadows of prominences.

Galileo also explains the faint illumination of the moon's disk at new moon as due to earthlight, an explanation which had already been advanced a century earlier by Leonardo da Vinci, whose statements we reprinted in this JOURNAL, October 1946.

Galileo very cleverly determined the height of some lunar mountains by measuring the distance from the terminator, or illuminated portion of the moon, at which the mountain peak on the night side of the moon was visible because it had sufficient altitude to be in sunlight. His determination is expressed in the Italian mile which is 0.925 of an English mile, and he concludes that there are mountains on the moon four miles high, whereas the mountains on earth do not reach above one mile. Accurate determinations of lunar mountain height by Beer and Maedler two centuries later showed six mountains which exceeded 19,000 British feet in height. Although Baldwin says that Galileo has somewhat overestimated the heights of any mountains that could be determined by his method, actually Galileo's understanding of the heights of lunar mountains was closer to reality than his ideas of the heights of mountains right here on earth!

Calculation to show that the height of some lunar mountains exceeds four Italian miles

I think that it has been sufficiently made clear, from the explanation of phenomena which have been given, that the brighter part of the Moon's surface is dotted everywhere with protuberances and cavities; it only remains for me to speak about their size, and to show that the ruggednesses of the Earth's surface are far smaller than those of the Moon's; smaller, I mean, absolutely, so to say, and not only smaller in proportion to the size of the orbs on which they are. And this is plainly shown thus:—As I often observed in various positions of the Moon with reference to the Sun, that some summits within the portion of the Moon in shadow appeared illumined, although at some distance from the boundary of the light (the terminator), by comparing their distance with the complete diameter of the Moon, I learnt that it sometimes exceeded the one-twentieth (1/20th) part of the diameter. Suppose the distance to be exactly 1/20th part of the diameter, and let the diagram represent the Moon's orb, of which CAF is a great circle, E its centre, and CF a diameter, which consequently bears to the diameter of the Earth the ratio 2:7; and since the diameter of the Earth, according to the most exact observations, contains 7000 Italian miles. CF will be 2000, and CE 1000, and the 1/20th part of the whole CF, 100 miles. Also let CF be a diameter of the great circle which divides the bright part of the Moon from the dark part (for, owing to the very great distance of the Sun from the Moon this circle does not differ sensibly from a great one), and let the distance of A from the point C be 1/20th part of that diameter; let the radius EA be drawn, and let it be produced to cut the tangent line GCD, which represents the ray that illumines the summit, in the point D.



Then the arc CA or the straight line CD will be 100 of such units, as CE contains 1,000. The sum of the squares of DC, CE is therefore 1,010,000, and the square of DE is equal to this; therefore the whole ED will be more than 1,004; and AD will be more than 4 of such units, as CE contained 1,000. Therefore the height of AD in the Moon, which represents a summit reaching up to the Sun's ray, GCD, and separated from the extremity C by the distance CD, is more than 4 Italian miles; but in the Earth there are no mountains which reach to the perpendicular height even of one mile. We are therefore left to conclude that it is clear that the prominences of the Moon are loftier than those of the Earth.

METEOR NEWS

By Peter M. Millman, *Dominion Observatory, Ottawa*

It is now just eleven years since I last contributed Meteor News to the Journal and a great deal has happened in that interval. Among other things the field of meteoric astronomy has assumed a new importance. Whereas previously this subject occupied the attention of relatively few professional scientists, now active and extensive programmes of meteor observation are being carried out at a number of institutions by both astronomers and physicists.

This has come about for two chief reasons. First, instrumental techniques, both photographic and radio, have taken great strides, making possible the collection of large amounts of quantitative meteor data in a relatively short time. Second, the current interest in the upper atmosphere occasioned by the development of jet aircraft and high altitude rockets has spot-lighted all methods by which we can study the physical conditions far above our heads.

At the Dominion Observatory, where I am now located, meteoric astronomy has for some years been one of the major research activities of the Stellar Physics Division. In reviving Meteor News at this time it is planned to print brief items of interest in this field and to publish accounts of various series of meteor observations carried out in Canada by both professional and amateur groups.

Observations by the Regina Astronomical Society

I have a large backlog of observations received from various Centres of the Society and from other groups and individual observers. Two of the most active groups in organizing and carrying out meteor observing have been the Montreal Centre of the Royal Astronomical Society of Canada and the Regina Astronomical Society. This latter group is an independent organization which has had a long history and which has recently shown increased interest in all types of observing programmes.

Regina observations of the Perseid shower were carried out in 1950 and 1951, and of the Geminid shower in 1950. These were under the direction of their president, Mr. J. V. Hodges, and their secretary, Mr. R. J. Harper. During the Geminid programme they had a rather amusing interlude with the Regina police force. Apparently someone reported that a strange ritual seemed to be taking place involving deck chairs and blanketed figures at dead of night in weather conditions when most people were enjoying the warmth of their own homes. The police

investigated and it took them some time to gather the full import of what was going on. However, they eventually became convinced that here was a group of reputable citizens, in spite of their queer taste in recreation, and the incident ended happily all round.

In 1950 Perseid observations were carried out on Aug. 11/12, 12/13 and 13/14. The first two nights were generally cloudy but the last was clear. The following observers took part:

D. Fast, R. J. Harper, J. V. Hodges, Mrs. J. V. Hodges, A. Lipton, T. R. MacFarlane, McClung, A. M. Nilson, J. Pettick, D. Rhods, J. J. Stillwell, H. Williams.

The Geminids were observed in 1950 on Dec. 10/11 and 11/12. Both nights were clear but on the first there was a slight aurora and on the second some haze near the horizon. The observers were as follows:

R. J. Harper, J. V. Hodges, Mrs. J. V. Hodges, W. Kinsman, A. M. Nilson, J. Nilson, H. Williams.

In 1951 the weather prevented all Perseid observations except on one night. However, on Aug. 11/12 a large number took part, being divided into four teams, one facing in each cardinal direction. All those assisting in this programme are listed below:

T. Apperley, R. Catterson, K. Collett, D. Cummin, P. Curtiss, Mrs. J. Dunn, Mrs. H. R. Gilbert, Miss M. Gilbert, Mrs. C. C. Hilgers, J. V. Hodges, Mrs. J. V. Hodges, Miss E. Lumsden, T. R. MacFarlane, A. M. Nilson, J Nilson, G. Osterried, J. Pape, J. J. Stillwell, J. Thauberger, Miss Q. Thomas, R. Thompson, Miss A. Trifunov, A. Winestock, S. Winestock.

The numbers of meteors observed and the observing periods are listed in Table I. Plotting was carried out for the summer observations but not in December. The magnitude distributions for the four clear nights are summarized in Table II. The hourly rates have been reduced to six observers by the factors published in the JOURNAL, vol. 28, p. 139, 1934, and have been plotted in the figure.

TABLE I

Date	Period or Observation M.S.T.	Mean No. of Observers*	Meteors Observed	
			Shower	Non-Shower
1950 Aug. 11/12	10.00–11.00	4	32	5
Aug. 12/13	10.10–01.30	6	60	7
Aug. 13/14	09.00–11.50	4	78	25
Dec. 10/11	08.00–10.00	4	18	10
Dec. 11/12	08.00–10.00	3	32	5
1951 Aug. 11/12	09.10–12.10	8	150	38
		Totals	370	90

*Exclusive of recorders.

I would like to congratulate the Regina group on a good beginning to their observational activity. They have recently acquired a small building and this is being developed into an observatory and headquarters for the Society. I am sure we shall be hearing from them again.

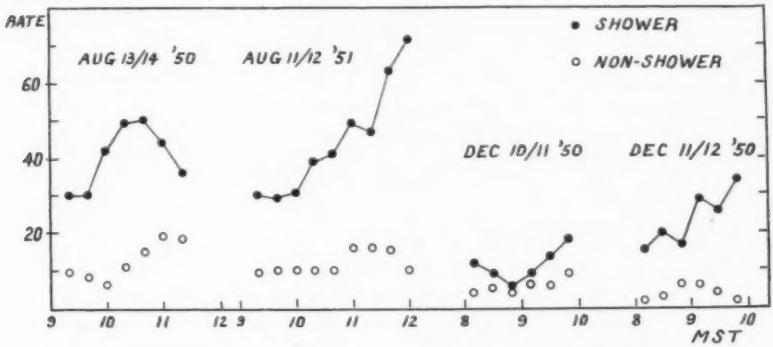


FIG. 1. The hourly rates of meteors observed visually at Regina and reduced to a standard observing unit of six observers, plotted against Mountain Standard Time.

TABLE II

Magnitude	−2	−1	0	1	2	3	4	5	Totals	Mean Mag.
1950										
Aug. 13/14										
P		2		8	13	10	41	4	78	3.15
N				1	5	5	11	3	25	3.40
1950										
Dec. 10/11, 11/12										
G	1	3		6	9	17	9	5	50	2.62
N		1		4	5	2	3		15	2.07
1951										
Aug. 11/12										
P		2		7	27	56	55	2	149	3.07
N				2	8	8	17	3	38	3.32

NOTE BY THE EDITOR

From 1934 to early in 1941 Dr. P. M. Millman had published a section called "Meteor News" in this JOURNAL, and owing to his enthusiasm and organization, many groups made systematic observations of meteors. In January 1941 Dr. Millman entered the Air Force. After the war he went to the Dominion Observatory in Ottawa, where he continued his research on meteors. We are pleased that he has now consented to re-establish "Meteor News" in the JOURNAL.

MEETINGS OF THE SOCIETY

AT TORONTO

October 9, 1951.—The meeting was held at the David Dunlap Observatory, Richmond Hill. The chairman was Mr. F. L. Troyer, President.

Twenty-one persons were nominated for membership in the Society, and there were two transfers, one from each of the Montreal and Saskatoon Centres.

The night was clear and an ideal one for a visit to the Observatory. Dr. Heard welcomed the Society on behalf of the Observatory Staff, and Mr. W. R. Hossack gave a short talk on two instruments being designed and built at the Observatory—instruments originated by the late Dr. F. S. Hogg. The first of these is a combination exposure meter, semi-automatic guider and photometer for the 74-inch telescope. The second is an oscilloscopic plate measurer to be used for radial velocity, absolute magnitude, and other determinations.

The meeting adjourned to the dome, where Mr. R. L. Baglow demonstrated the telescope. Small telescopes were placed on the lawn by the Telescope Makers Group, which held a separate meeting after the larger one had adjourned.

W. R. HOSSACK, *Recorder.*

October 30, 1951.—The meeting was held in McLennan Physics Laboratory with the President, Mr. F. L. Troyer, in the chair.

Twenty-one candidates were elected to membership in the Society. These were:

Mr. Gilbert K. Dobbin, 515 Gladstone Ave.
Mr. James H. Goldie, 211 Quebec Ave.
Mr. Robert R. Roenicke, 14 Spring Garden Rd.
Mr. Walter Earl Smith, R.R.3, Waterford, Ont.
Mr. James Armstrong, 27 Ridge Drive.
Mr. W. Archie Bernhardt, 26 St. Clair Ave., Kitchener, Ont.
Miss Marjorie C. Bowman, M.A., Dept. of Zoology, University of Toronto.
Mr. Hugh J. Brown, 211 College St.
Mr. William J. Budd, 57-33rd St., Long Branch.
Mr. James W. Griffiths, 2 Macauley Ave.
Mr. Melvin A. Heidrich, 161 Kane Ave.
Mr. Hartley G. Ionson, 34 Mattice Ave.
Mr. Glenn H. Lewis, 177 Roxborough St. E.
Miss Helen McBride, P.O. Box 338, Newmarket, Ont.
Mr. Theodore Michalski, 63 Augusta St.
Dr. Jack Pollack, M.D., 55 Ava Rd.
Mr. Michael Reed, 264 Roxborough St. E.
Mr. Wallace A. Russell, 45 Homewood Ave.
Miss Mary Semenoff, 92 Sydenham St.
Mr. Ian A. Taylor, 7 Armadale Ave.
Mr. H. A. van Iterson, Mech. Eng., 120 Laurel Ave., R.R.1, Islington.

There were also the following two transfers:

Mr. Philip J. Linden, 801, 137 Wellington St. W., from Montreal Centre.

Mr. Jesse Ketchum, 7-13th St., New Toronto, from Saskatoon Centre.

Mr. Raymond Pearce was nominated by Mr. Kurt Frankel to serve a second year as National Council Representative for the Toronto Centre. The nomination was seconded by Miss Ruth Northcott.

Dr. Ainslie introduced the speaker, Dr. H. E. Duckworth, Professor of Physics at McMaster University. Professor Duckworth spoke on "Weighing Atoms—Precise Measurement of Atomic Masses".

For this evening, the astronomers had to turn their thinking from the very large to the very small. Once one had conceived the scale of atomic size, an analogy could be drawn between an atomic system and the solar system, the nucleus being the sun and the outer electrons the planets traveling in their orbits. An atom consists of protons and neutrons in the nucleus, and electrons moving in circular or elliptical orbits about it. It is the number of protons in the nucleus that determines the chemical properties of an element, but there do exist atoms which have the same chemical properties yet differ in mass. These are called isotopes, and most elements have several.

Measurement of atomic mass is made by passing a beam of ions (atoms with one or more electrons removed, and therefore charged particles) through a magnetic field. This causes the ions to follow a circular path, the radius of which depends on the mass. One of the best known mass spectrographs, as these instruments are called, is that constructed by Dempster in which the electrodes supply the ions. The ions may be allowed to fall on a photographic plate, and the distance of the line formed by ions of one element from some line caused by atoms of known mass may be measured. The oxygen isotope O^{16} is taken as the standard of mass.

The masses of atoms are not even numbers; that is, there is a small difference between the actual mass and the nearest whole number which is known as the mass number and is equal to the sum of the number of protons and neutrons in the nucleus. When two hydrogen atoms and two neutrons are brought together, the total mass is not that of a helium atom as one would expect, but there is a mass loss. This mass is lost in the form of energy. The atoms which have the smallest difference between actual mass and mass number are the most stable. It is this energy release which is responsible for uranium fission. When a neutron hits U^{235} (the number is the mass number) there is formed the very unstable isotope U^{236} and this splits almost immediately into Mo^{100} and Xe^{136} with a large release of energy. A process similar to this, only involving hydrogen, may be responsible for the production of the sun's energy.

The speaker was thanked by Miss Ruth Northcott, and the meeting was adjourned.

BARBARA CREEPER, *Recorder, pro tem.*

Nov. 13, 1951.—The meeting was held in the McLennan Physics Laboratory, with Mr. F. L. Troyer, President, in the chair.

Four new members were elected to the Society. These were:

Miss Doreen C. Letsche, 1005 Mt. Pleasant Rd.

Miss Mary Lutton, 525 Clinton St.

Miss Joyce E. Webb, 26 Hatherley Rd.

Mr. Zoel Roy, 31 Cecil St.

Mr. Myland nominated the three past presidents, Miss Northcott, Dr. Heard and Mr. Clute, to form a nominating committee for next year's executive. Mr. Dalton seconded the motion.

Mr. Troyer expressed his sorrow on reading about the passing of Prof. DeLury, the oldest life member of the Society, and also a past president.

Mr. Ed. Greenwood gave an account of the Astronomical League meeting at Chapel Hill, North Carolina, where he was the only Canadian present. He described the preparations and what they could see of the annular eclipse, which, because of cloud, was unfortunately not very much. He also described the Fels Planetarium at Philadelphia and the Moorehead Planetarium at Chapel Hill. Here they had talks on observing techniques and a chance to try them out. Instances of this were the observation of sample meteor showers, planet and fireball plotting.

This led to a general discussion of meteor and fireball observing and the importance of reporting the time and place of observations was stressed. Miss Northcott gave suggestions on how amateurs can be useful in observing variable stars and aurorae. Occultations were also discussed with amateur observing in mind and the need for great accuracy was pointed out. Occultation observations are important to keep track of the path of the moon, and lately to measure parallaxes. The discussion gave evidence of the important role in astronomy which amateurs may play.

BARBARA CREEPER, *Recorder, pro tem.*

LONDON CENTRE

Honorary President—H. R. KINGSTON, Ph.D. *President*—ALBERT EMSLEY.
Vice-President—REV. W. G. COLGROVE.
Secretary-Treasurer—R. E. WINTERS, 1142 Richmond St. N., London.
Council—R. H. COLE, Ph.D.; W. GORDON GRAHAM; MRS. BERNARD JOHNSON; GORDON R. MAGEE, Ph.D.; GEORGE W. WALDEN; and *Past President*—A. J. WATT, M.D.

VANCOUVER CENTRE

Honorary President—G. M. SHRUM, Ph.D. *President*—M. T. SPENCE.
Vice-President—R. J. CLARK, Ph.D. *Treasurer*—MRS. C. A. ROGERS.
Secretary—E. M. PRICE, 3831 Dunbar St., Vancouver. *Recorder*—O. BLUH, Ph.D.
Council—A. M. CROOKER, Ph.D.; C. W. DEANS; G. E. FROSTRUP; D. INGE; C. JORGENSEN; CAPT. C. A. MCDONALD; A. OUTRAM.

EDMONTON CENTRE

Honorary President—J. W. CAMPBELL, Ph.D. *President*—S. G. DEANE.
Vice-Presidents—E. PHIBBS. *Treasurer*—MISS A. M. P. SMITH.
Secretary—E. H. GOWAN, Ph.D., University of Alberta, Edmonton.
Librarian—E. S. KEEPING. *Assistant Librarian*—MISS E. VALENS.
Council—H. M. BURT; L. E. GADS; S. F. PAGE; MRS. E. SIEMENS; V. WILLIAMS.
Social Hostesses—MISS M. BOWMAN; MISS I. FORTUNE; MRS. R. N. SHAW.

QUEBEC CENTRE

Patron—MGR. FERDINAND VANDRY, P.A., V.G., Recteur de l'université Laval.
Président—ALBERT DUBERGER. *Vice-Président*—ALFRED DION.
Secrétaire-trésorier—PAUL-H. NADEAU, 275 rue de Saint-Cyrille, Québec.
Assistant secrétaire—MLLE. LOUISE LACHANCE.
Conseil—L'ABBE ROSARIO BENOIT; JEAN-PIERRE BERNIER; ALFRED DUMONT; GERARD LAFONTAINE; JEAN-CHS. MAGNAN; DAVID I. MCGILL; LIONEL-PIERRE PELOQUIN; LUCIEN POULIOT; OSCAR VILLENEUVE.

WINDSOR CENTRE

Honorary President—J. J. COUGHLIN, B.A. *President*—R. WARWICK, B.A.
Vice-President—HENRY LEE, B.S.E.E. *Treasurer*—WILLIAN PERSON.
Secretary—ROBT. C. BRADLEY, M.A., 3774 Montcalm Ave., Windsor.
Librarian—GORDON WILSON. *Assistant Librarian*—DONALD LEVER.
Council—DANIEL C. BAWTENHEIMER; CHAS. A. BELL, B.A.; HUGH S. CUNNINGHAM; B.A.; GEO. CURRIE, B.A.; CYRIL HALLAM, B.A.; ALMON HARE, B.Sc.; CAMERON MONTROSE, B.A.; LORNE ROGERS, B.A.; C. RUSSEL; E. H. THISTLETHWAITE.

SASKATOON CENTRE

Honorary President—W. PETRIE, Ph.D. *President*—G. R. SMALL.
Vice-President—R. H. TRICKEY.
Secretary-Treasurer—R. E. JENSEN, University of Saskatchewan, Saskatoon.
Council—B. W. CURRIE, Ph.D.; A. E. FALK; J. KETCHUM; L. N. LEVALLEY; A. E. MILES; and *Past Presidents*—J. R. MARTIN; J. H. IRWIN.

GUELPH CENTRE

Honorary President—HENRY H. WESTOBY. *President*—HAROLD SEEKINS
Past President—PROF. R. C. MOFFATT. *1st Vice-President*—PROF. V. C. LOWELL.
2nd Vice-President—FRANK BRAUCHI. *Treasurer*—ROY SCHNURR.
Secretary—STEWART G. BRUCE, JR., 179 Eramosa Road, Guelph.
Council—W. T. PATTERSON; S. B. MACKAY; D. HATCH; S. LEWIS; MRS. G. CURRIER; MRS. V. C. LOWELL; MRS. P. MOCKFORD.

CENTRE FRANCAIS DE MONTREAL

Président—DELISLE GARNEAU. *Vice-Président*—J. AMEDEE BUREAU.
Secrétaire-trésorier—MLLE. FLEURANGE LAFOREST.
Rapporteur—JEAN ASSELIN, 6665 St. Delis St., Montreal.
Bibliothécaire—ROGER BONIN. *Directeur des Observations*—J. EDGAR GUIMONT.
Conseil—GERARD BEAUDRY; BERNARD BOUCHER; HECTOR COLETTE; MLLE. MARCELLE GAUVREAU; R. W. GRIGNON; JOSEPH LEDUC; JEAN NAUBERT; REVEREND FR. ROBERT, f.e.c.

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY
OF CANADA

VOLUME XLVI, No. 1 JANUARY–FEBRUARY, 1952 WHOLE No. 394

PAGE

Articles

The Story of Pluto *Dinsmore Alter* 1

A Spectrographic Study of the Double-lined Binary H.D. 27483 *Ruth J. Northcott* and *K. O. Wright* 11

Eighty-sixth Meeting of the American Astronomical Society *J. F. Heard* 20

H. C. Schumacher and the Observatory at Altona *W. Voss* 22

Review of Publications

The Heavens are Telling by Urana Clarke (*I. K. Williamson*); L'Astrologie by Paul Couderc (*J.F.H.*) 24

Notes and Queries

Vesta (*R.J.N.*); Work at Radcliffe Observatory (*C.A.C.*); Chubb Crater, Ungava (*R.J.N.*); Robert Grant Aitken, 1864–1951; Alfred Tennyson DeLury, 1864–1951 (*C.A.C.*) 26

Out of Old Books

Galileo and the Surface of the Moon *Helen Sawyer Hogg* 30

Meteor News

Peter M. Millman 35

Meetings of the Society

At Toronto 38

Address of Editors: David Dunlap Observatory, Richmond Hill, Ont.

Business correspondence and remittances should be addressed to J. H. Horning, Treasurer of the Society, 3 Willcocks St. Toronto.
$3.00 per annum, Single number, 50 cents.
Subscription to the JOURNAL is included in membership fee.